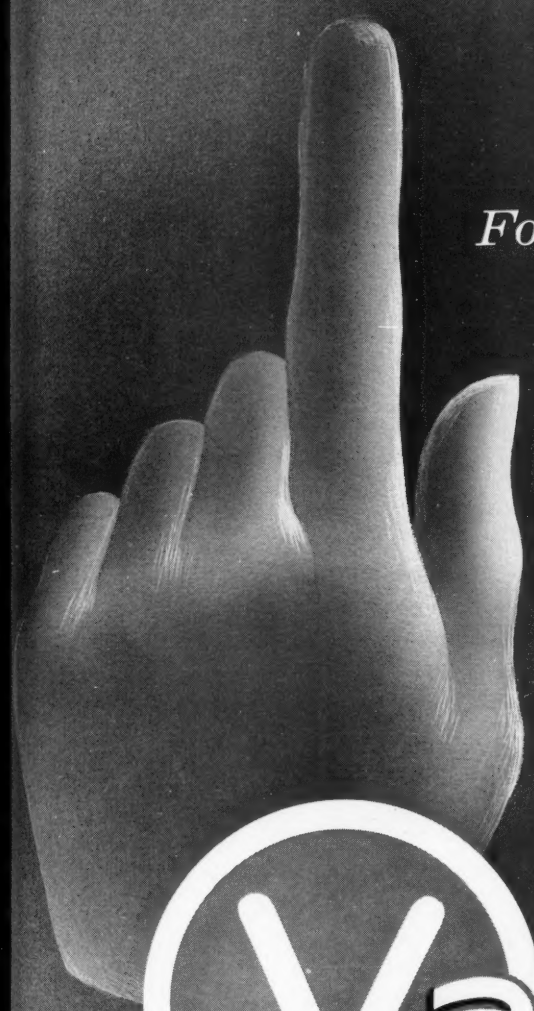
OCTOBER 1955

WIRE AND WIRE PRODUCTS



For 85 *years...*

FIRST

IN WIRE DRAWING MACHINERY
DESIGN, PERFORMANCE
and ACCEPTANCE
by the Industry

Vaughn

"Quick on the Draw"

see pages 1188 A, B, C and D

OFFICIAL PUBLICATION OF THE WIRE ASSOCIATION

Payoffpak...®

it's new...it's different... it's ideal for handling and processing WIRE!

PAYOFFPAK—Continental's newest fibre container—offers wire manufacturers and fabricators a revolutionary new development in wire packaging, handling and dispensing.

SAVES WORK—Wire is automatically packaged in the Payoffpak as it is drawn, eliminating such operations as stripping, tying, handling, splitting and wrapping.

SAVES TIME—Payoffpak can hold 600 lbs. Downtime on the wire drawing machine, due to stripping operations, is greatly reduced.

ELIMINATES REELS—Single standard-size Payoffpak eliminates reels and need for wide range of block sizes.

CUTS SHIPPING COSTS—Inexpensive, light-weight Payoffpaks travel for less because of extremely light tare weight.

HANDLES AND STACKS EASILY—In-plant handling of Payoffpaks is easy with conventional hand trucks. High stacking strength means you can use maximum storage space, too.

A survey indicates that often more than 50 labor steps are needed to convert 500 pounds of steel wire in standard eight inch coils—but you can do the same job with Payoffpaks in an average of five operations. No wonder they are calling this new container "the long-playing record of the wire industry" See how Payoffpaks can pay off for you. Call Continental for complete information on this exciting new way to package, handle and dispense wire.

CONTINENTAL CAN COMPANY

FIBRE DRUM DIVISION • VAN WERT, OHIO

New York • Philadelphia • Pittsburgh • Tonawanda • Cleveland • Chicago
Atlanta • St. Louis • San Francisco • Los Angeles • Eau Claire

"America's Finest Wire Drawing Lubricants"

Created for Your Plant

WELCOME TO CHICAGO!!

Standard Industrial has pioneered in most of the outstanding contributions to better wire drawing through better lubricants. Consult Standard Industrial for the solution of your difficult problems.

We are looking forward to seeing you at the Convention Nov. 14–17th

Standard Industrial **COMPOUNDS CO., INC.**

4600 WEST FERDINAND STREET
CHICAGO 44, ILLINOIS
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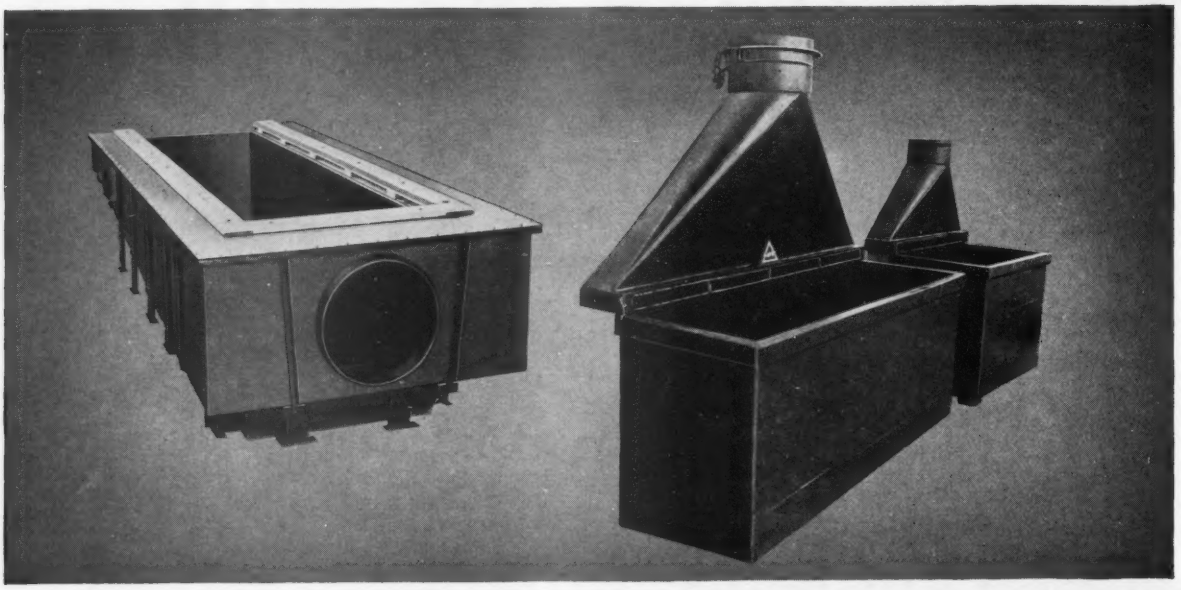
WHERE HAVEG EQUIPMENT IS INSTALLED

TRADE MARK REG. U. S. PAT. OFF.

PICKLING, PLATING, DEGREASING TANKS • BASKETS • PIPING • VALVES
AGITATORS • PUMPS • FUME DUCT • BIFURCATORS • HOODS



Metal Finishing Corrosion has been Controlled!

All Haveg equipment has extra long life, extreme resistance to corrosive chemicals, and can be used continuously in a high range of process temperatures with complete safety.

Because Haveg corrosion-resistant tanks prevent specking or flaking, the number of rejects is reduced, finished plating is uniform. Solutions do not build up on Haveg, reducing clean-up time.

Molded Haveg tanks are made in a single piece construction. Any size, style, baffle arrangement can be supplied to fit your process. They are made for long service life to improve production.

Remember, Haveg is not a coating or tank lining. It is a moldable rigid, plastic material made from acid-digested asbestos and specially selected synthetic resins. Throughout its entire mass, Haveg is resistant to most acids and salts, chlorine, practically all solutions used for finishing metals.

Haveg can help you make your finishing operations more profitable and less subject to the waste of corrosion. Call the sales engineer listed and write for 64-page Bulletin F-6 which shows tank sizes, shapes, chemical ratings . . . the complete Haveg story.

NEW HAVEG POLYESTER GLASS TANKS

Haveg polyester glass tanks for the metal-finishing industry are tough, can take hard knocks. They withstand the attack of acids normally used and are non-conductors of electricity. Where necessary, walls can be reinforced with corrugated construction or with steel ribs molded into the Haveg tank. Overflows for rinses also can be molded to fit your system. Write for more details.

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HAVEG CORPORATION

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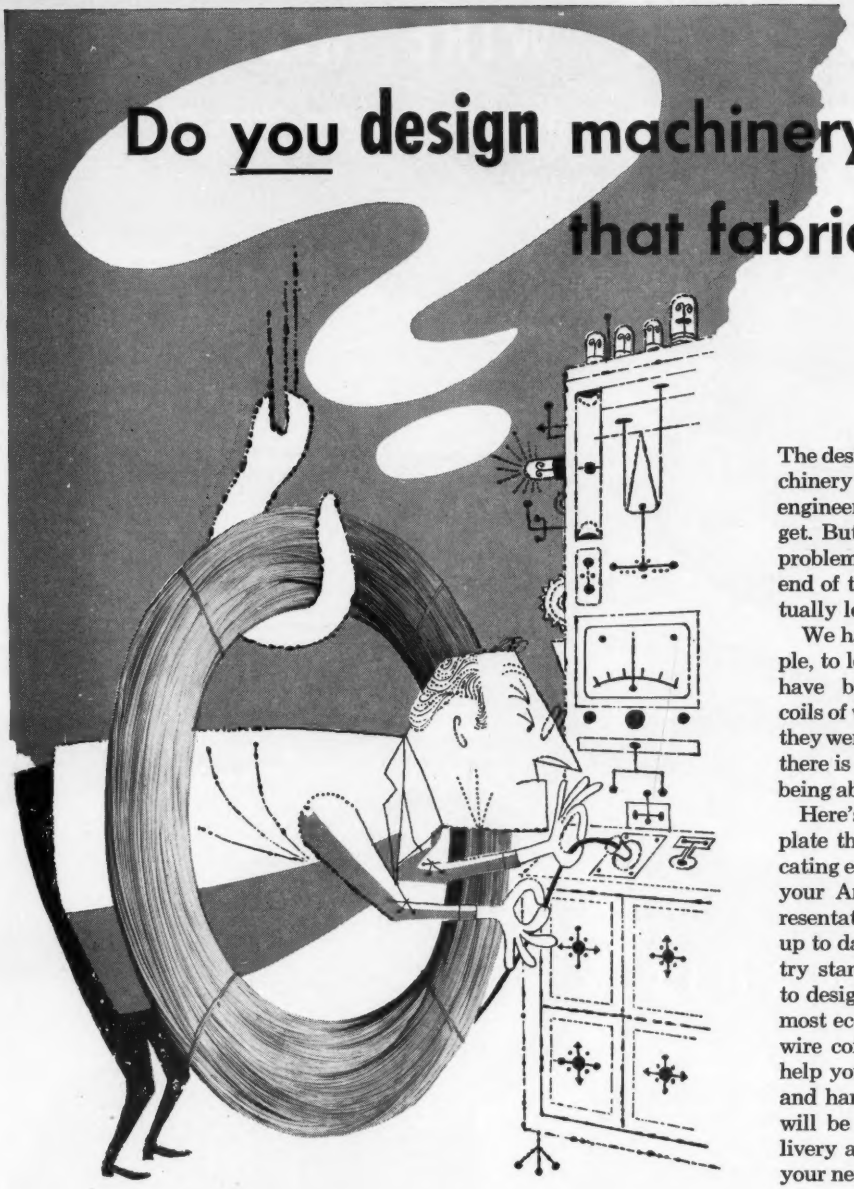
Do you design machinery that fabricates wire?



The design of Wire Fabricating machinery is one of the most rigorous engineering assignments you can get. But no matter how tricky the problems, do not forget the front end of the machine—where you actually load the wire.

We have been amazed, for example, to learn that certain customers have been buying non-standard coils of wire for years, thinking that they were *standard* coils. Naturally, there is a shipping delay due to not being able to use standard material.

Here's an offer: If you contemplate the design of any wire fabricating equipment, get in touch with your American Steel & Wire representative first. Let him bring you up to date on the latest wire industry standards—and show you how to design the equipment to use the most economical types and sizes of wire coils. He will also be glad to help you lay out your wire storage and handling facilities. The result will be lower costs and faster delivery and better production using your newly designed equipment.

USS AMERICAN MANUFACTURERS WIRE

AMERICAN MANUFACTURERS WIRE

AMERFINE—*High quality fine wire.*

AMERSPRING—*music steel spring wire.*

AMERLOY—*alloy heading wire.*

AMERTEMP—*heavy-duty oil-tempered wire.*

AMERHEAD—*uniform heading wire.*

AMERSTITCH—*extra-tough metal stitching wire*

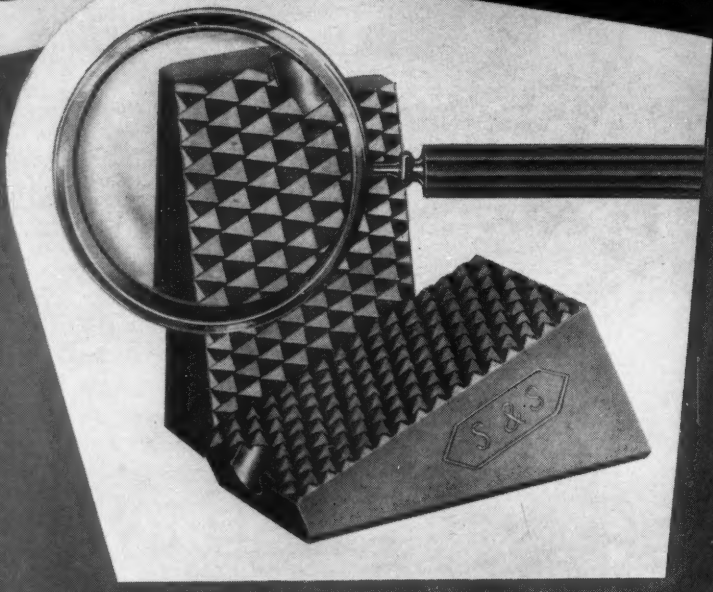
USS

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL CORPORATION, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

UNITED STATES STEEL

Sjogren WIRE MILL TOOLS

Used By Wire Men Who Want the Best!



CRAFTSMANSHIP

Early craftsmanship manifested itself in products that, today, are usually classed as objects of art . . . beautiful in themselves, but generally speaking, non-utilitarian. Such an example of the sixteenth century gunsmiths' and goldsmiths' arts are exhibited in the fine chasing on the steel parts and solid gold barrels of a priceless pair of pistols made for European royalty. Todays' modern craftsmanship requires no less skill and finesse to produce products that are utilitarian, efficient, and income producers for their owners. Such are all regular and special items in the Sjogren line of wire mill tools. Each tool is designed and produced by master craftsmen whose know-how and skill builds into the product, such as the Sjogren Wedge Grip Jaws, that ruggedness for continued use and that suitability to purpose which make them second to none.

Photograph is Wheellock pistols and Simarigen Castle Museum courtesy Dexter Antique Arms, Los Angeles, California

SJOGREN TOOL AND MACHINE CO., INC.

Tools for the Wire Industries

14 SWORD STREET, AUBURN, MASSACHUSETTS

WIRE AND WIRE PRODUCTS*

Reg. U. S. Pat. Off.

A monthly publication devoted to the production of Wire, Rod and Strip, Wire and Rod Products and Insulated Wire and Cable.

DRAWING — ROLLING — EXTRUDING — FORMING — FABRICATING

Vol. 30 October, 1955 No. 10

Designated as Official Publication By The Wire Association

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SIX ADVANTAGES from just ONE DIP!

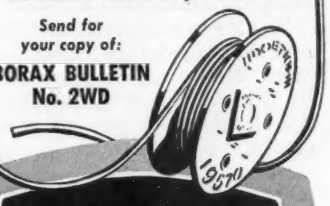
COAT WITH BORAX 5 MOL.

Here are the advantages you get when your stock is Borax-coated...

1. FASTER ACID NEUTRALIZING
2. LONGER DIE LIFE
3. FASTER BUTT WELDING
4. BETTER WORKING CONDITIONS
5. LONGER STORAGE SAFETY
6. RUST DOES NOT FORM

One dip puts on a Borax coat that is tight, yet pliable, and dries in a few minutes. It provides a good vehicle for your drawing lubricant and won't flake off. Borax-coated rods are a lot cleaner to handle in transit and are protected from rust while in storage. Try BORAX or BORAX 5 MOL on *your* stock!

Send for your copy of:
BORAX BULLETIN No. 2WD



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DIVISION OF BORAX CONSOLIDATED, LIMITED
NEW YORK • CHICAGO
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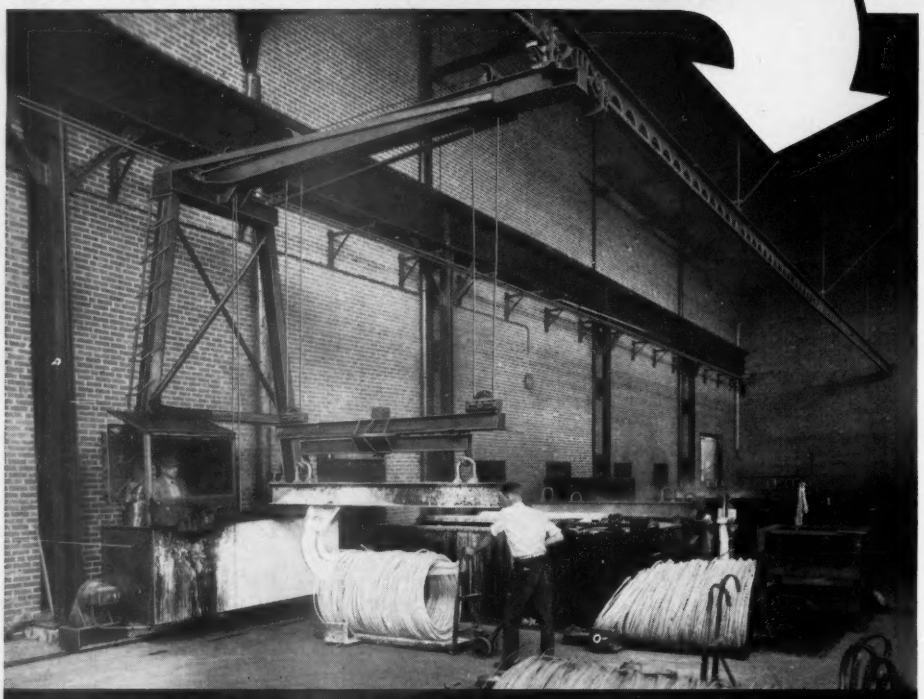
MANUFACTURERS OF FAMOUS "20 MULE TEAM" PACKAGE PRODUCTS

CUT ROD AND WIRE CLEANING COSTS
THE CLEVELAND TRAMRAIL WAY

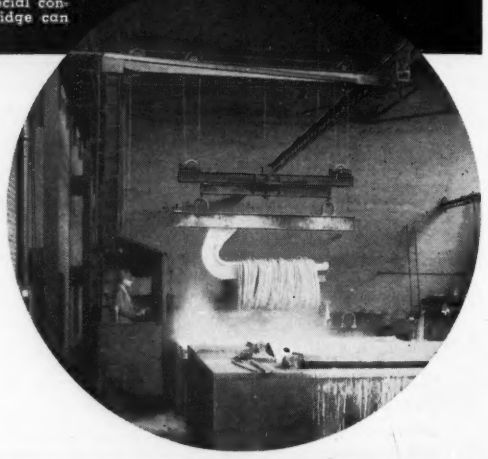


Hoisting machinery for this gantry crane is located next to operator's cab where protected from acids and fumes. Variations of this equipment have been built to suit special conditions. If desired, a movable trolley on gantry bridge can be furnished.

Nothing else that we know of can so cut costs and bring about other important advantages in a rod or wire mill, for the expenditure involved, as a modern Cleveland Tramrail cleaning house crane installation.

Cleveland Tramrail equipment completely revolutionizes cleaning house procedure and enables one man in the crane cab to run large tonnages through the cleaning cycle usually involving acid dip, water rinse, lime coating and baking. The equipment requires less than one-half the space for the old circular method and by the very nature of the layout used, a cleaner and more orderly room results.

The large number of installations now serving leading rod and wire producers attest to the advantages of the equipment. If you are interested in lower cleaning costs per ton by a method that quickly pays for the original investment, we suggest that you get the facts on Cleveland Tramrail cleaning house cranes.



3,300 lb. loads can be handled with this unit. Note the load bar is equipped with a swivel arrangement permitting turning the hook.

GET THIS BOOK!

BOOKLET No. 2008. Packed with valuable information. Profusely illustrated. Write for free copy

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THE CLEVELAND CRANE & ENGINEERING CO.
9216 EAST 288th STREET, WICKLIFFE, OHIO

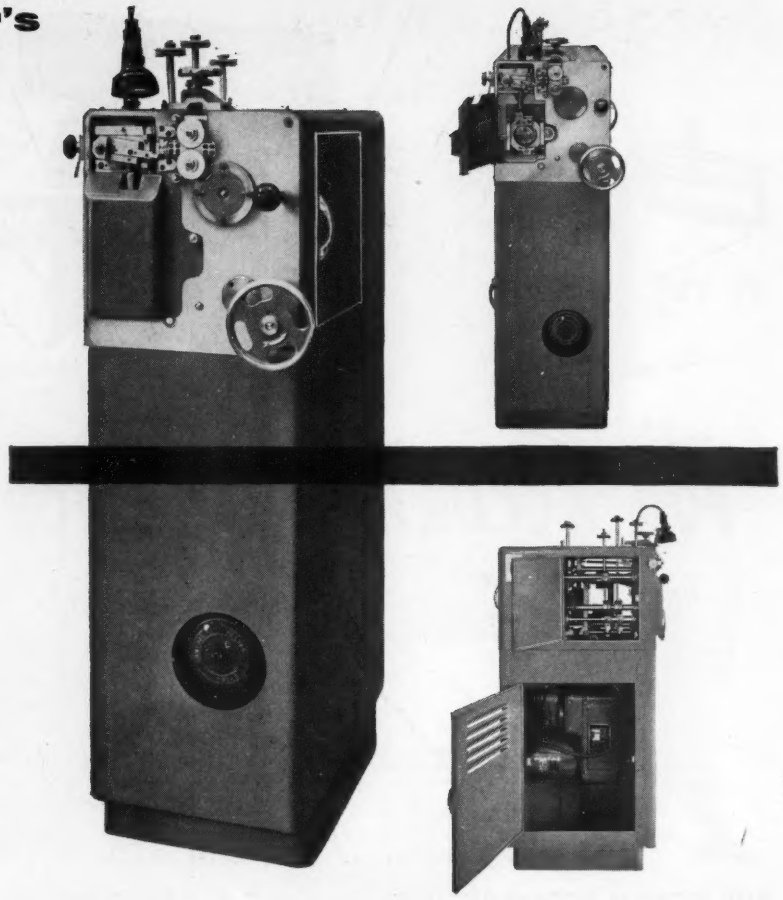
CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

Springmaker's Delight!

.... Torrington's new W-10A

Based on the famous W-10 Spring Machine which has long been standard equipment throughout the industry, Torrington now offers the modernized W-10A Springmaker. This versatile, high-production machine includes many new features, all of which contribute to ease of set-up, correct location of controls, "clean" design and lower maintenance.

Read the specifications. Then call or write for further information on how the W-10A can be put to work in your plant to speed your production and reduce your costs.



SPECIFICATIONS

Wire Diameter Range	.008" to .028"
Wire Length Per Spring	0" to 24"
Coil Range (O.D.)	$\frac{1}{16}$" to $\frac{7}{8}$"
Production	24 to 243 with motorized variable speed transmission 21 to 240 with electronic adjustable speed drive
Drives	½ HP motorized variable speed transmission ¾ HP electronic adjustable speed drive
Extra Wire Feed Gears	0" to 36" of .008 to .024 diameter wire 0" to 48" of .008 to .020 diameter wire
Special Wire Feeds	0" to 6½" (using standard wire feed gears reversed)
Attachments Available	Torsion spring coiling mechanism, double diameter spring control mechanism, continuous coiling, 10 roll—2 plane-quick-opening ball bearing straightener, 5 roll—single plane—quick opening ball bearing straightener
Floor Space	21" front x 28" deep
Wire Line Height	48"
Weight	695 lbs.

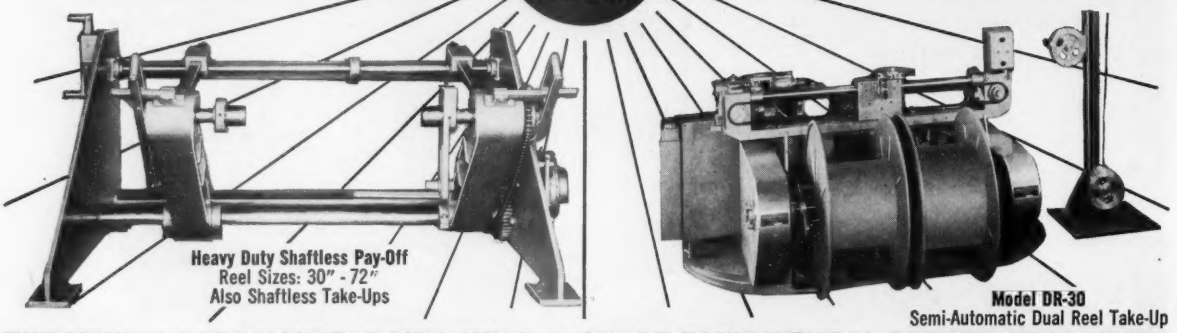
THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT

Model T-30
Take-Up or Re-Reeler

No. 4 Spark Tester
Automatic Resparking for Re-Reeling

CV Type Sparker
For Continuous Vulcanizing
or Plastic Extruding

FOR ACCURACY — DAVIS WIRE & CABLE EQUIPMENT — FOR DEPENDABILITY



Heavy Duty Shaftless Pay-Off
Reel Sizes: 30" - 72"
Also Shaftless Take-Ups

Model DR-30
Semi-Automatic Dual Reel Take-Up

THE NEWLY REDESIGNED *DAVIS WIRE & CABLE EQUIPMENT* IS BETTER THAN EVER

Modernized, streamlined and engineered for fast production of safely insulated wire and cable, the newly redesigned DAVIS ELECTRIC line of Spark Testers, Pay-Offs, Take-Ups, Counters, Spoolers, Traverses and Capstans is now offered as the finest ever conceived and produced by DAVIS ELECTRIC engineers. Before you buy, you owe it to your pocketbook as well as your business reputation to learn what this unexcelled machinery can do to better satisfy your customers (and your stockholders!). Refinements and advancement in designs qualify the 1955 DAVIS ELECTRIC line to surpass in performance previous DAVIS products in use in 80% of the industry's wire mills and some of which have been in operation for 15 years without maintenance problems!

What better tribute to quality can one ask?

Write for complete details and find out how DAVIS ELECTRIC can improve your wire and cable production and promote profit in your plant.

Davis ELECTRIC CO.

WALLINGFORD, CONN., U.S.A.

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SPARK TESTERS ★ SPOOLERS ★ TAKE-UPS ★ CAPSTANS
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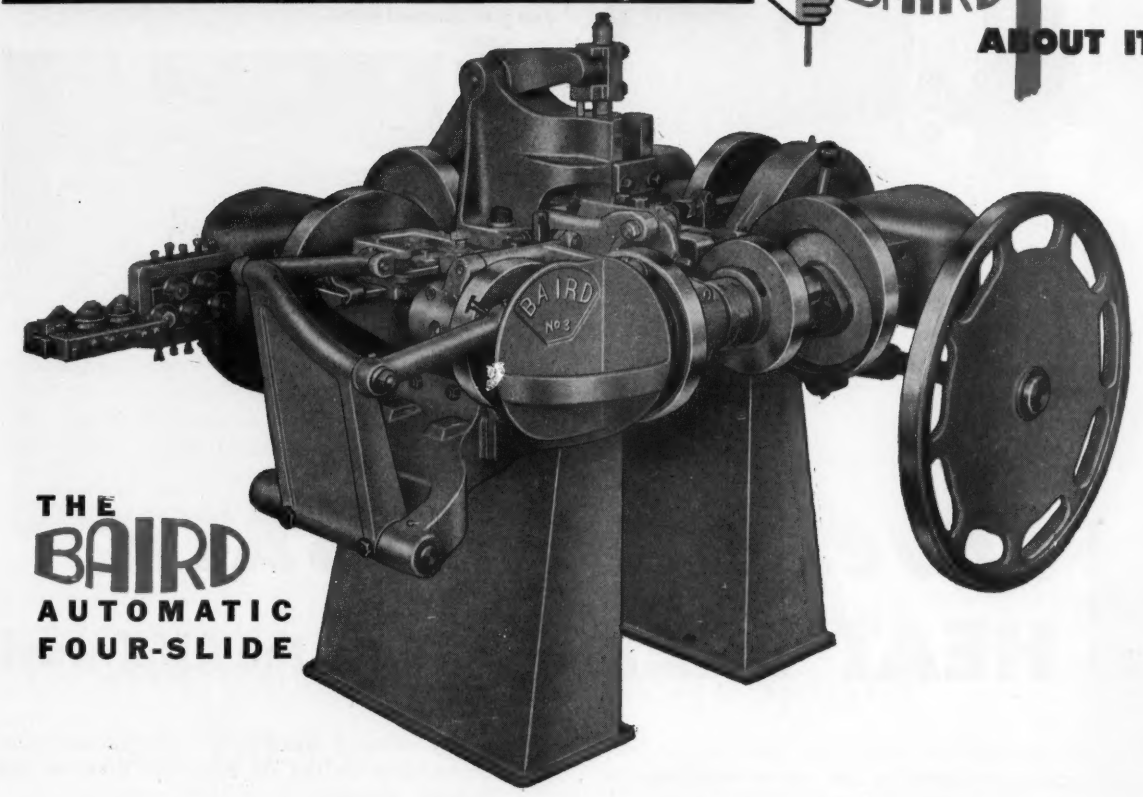
. . . IF IT'S A HIGH PRODUCTION PROBLEM . . .

ASK BAIRD ABOUT IT



THE BAIRD AUTOMATIC FOUR-SLIDE

NO MACHINE IN THE WORLD CAN MAKE A GREATER VARIETY OF PARTS . . . *OR PRODUCE THEM ANY FASTER*

Yet, new wire shapes, formed *by hand,* are continually submitted to us for tooling setups to produce them *automatically* on Baird Four-Slide Machines. We usually solve the problems.

Coiled wire is taken from a reel, is straightened, fed and cut off to the required length . . . then formed and ejected as a remarkably accurate part. The per-minute speed of production is almost unbelievable . . . and the unit cost likewise.

You may purchase your machine tooled for specific repetitive production, then add other tooling and attachments as required to increase the versatility of production of both wire and metal ribbon articles to the greatest degree.

Various sizes of standard machines give you a selection of wire lengths to 32½" . . . dia. to ½" . . . or flat ribbon metal products to 1½" wide.

Baird engineers will develop your tooling from your parts or from blueprints. The Baird Four-Slide Bulletin (Wire or Ribbon Metal) will open new avenues to low-cost competitive production. Your copy on request—write Dept. WP.

THE BAIRD MACHINE COMPANY
STRATFORD — CONNECTICUT

WHERE YOU WILL GET THE HELP OF SPECIALISTS ON THESE ESSENTIAL PRODUCTION PROBLEMS:

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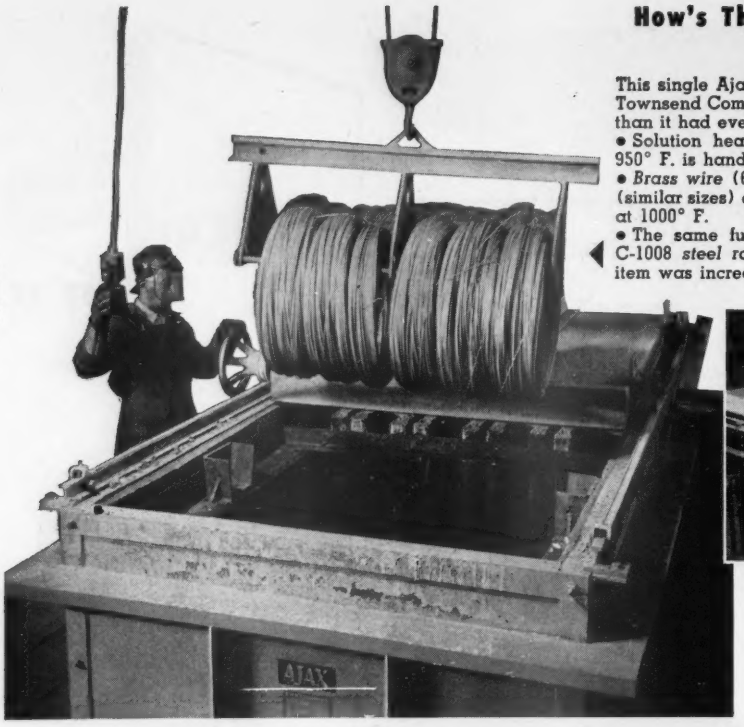
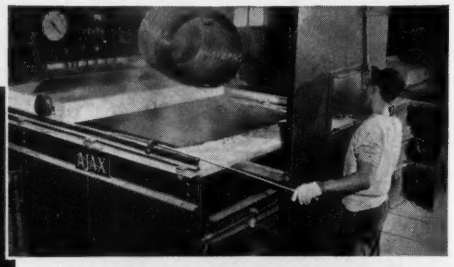


How's This for Heat Treating Economy PLUS Versatility?

This single Ajax Salt Bath Furnace does 3 different jobs for the Townsend Company, New Brighton, Pa. . . . and does each better than it had ever been done before.

- Solution heat treating of four different *aluminum alloys* at 950° F. is handled at 1,000 pounds per hour.
- *Brass wire* (65-35 from 1/16" to 3/8" diameter) and *copper wire* (similar sizes) annealed in batches of 1,000 pounds in 30 minutes at 1000° F.
- The same furnace is used for stress relieving cold headed C-1008 *steel rods* 1/2-inch in diameter. Production of this one item was increased 400%!



DONE IN MINUTES!

A 250-pound charge of stainless steel wire is quickly brought to annealing temperature of 1850° F. in this Ajax electric salt bath furnace. Wire is essentially used for welding rods.

Save! with SALT BATH HEAT TREATING...the AJAX way!

No other process can match the Ajax Electric Salt Bath Furnace, for speed or low cost of equipment in the heat treating of steel, and non-ferrous wire.

You get greater and faster production in less floor space. Quality is improved—wire is heated more uniformly. Atmospheric effects (scaling and decarburization) are eliminated.

Summing up—the advantages of the Ajax Electric Salt Bath Furnace in specific applications are:

PROCESS ANNEALING . . . Bigger furnace charges heat treated in minutes instead of hours . . . scale eliminated . . . lowest over-all equipment investment . . . smallest floor-space requirement.

DESCALING . . . More work handled in less time . . . greatly reduced metal loss . . . minimized acid consumption by the Du Pont, the Virgo or the "Kolene" process.

PATENTING . . . Faster production with greater product uniformity . . . lower operating costs and, in many cases, the elimination of a separate cleaning operation.

CLEANING, PREHEATING and FLUXING (preparatory to aluminizing or other special processing) . . . Clean, scale-free surfaces obtained more quickly and at appreciably less cost.

Write for case histories—or, better yet, send a representative batch of work to our laboratory for treatment to prove our claims—no obligation.

AJAX®
HULTGREN

Associate Companies: Ajax Electric Furnace Corporation, Ajax Engineering Corporation, Ajax Electrothermic Corporation

electric SALT BATH furnaces

AJAX ELECTRIC COMPANY • 928 Frankford Avenue, Philadelphia 23, Pa.

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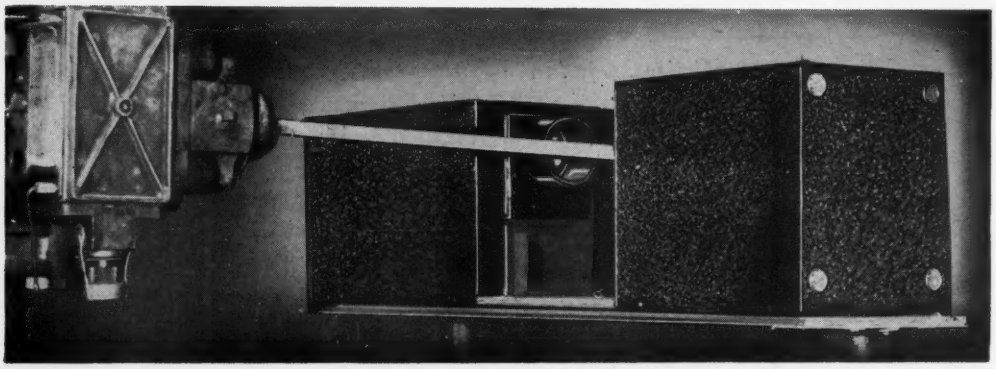
PLACE: NAVY PIER — CHICAGO

TIME: NOVEMBER 14-17, 1955



YOU HAVE READ ABOUT THE SERC GAUGES—NOW WE INVITE YOU TO SEE THEM.

WHEN YOU ATTEND THE WIRE ASSOCIATION CONVENTION VISIT OUR BOOTH NO. 419 AT THE AUTOMATION SHOW.

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2 EAST END AVE. • NEW YORK 21, N. Y.

OUR FOREIGN REPRESENTATIVE

ANDREW S. SZUCS, INC.

50 BROAD STREET

NEW YORK 4, N. Y.

WIRE • CABLE • CORD

EFFICIENT, MODERN SYSTEMS
FOR
ELECTRICAL WIRE & CABLE MANUFACTURING

• *CABLE LACQUERING SYSTEMS*

Conventional cellulosic, or other type, lacquers are applied in successive continuous coats from one to twenty-eight coats over fibrous braid wrapped primary conductors. One end, four ends, or eight ends of wire are handled continuously. System includes letoff, application, drying and constant tension takeup equipment.

• *WIRE ENAMELING SYSTEMS*

Natural and synthetic enamels, silicones, solution nylon, modified plastisol, and similar insulating coatings are applied to bare, cotton or glass covered wire in round, square or rectangular cross section. Ten or twenty simultaneous strands are handled. Systems are complete with letoff, preannealer, application system, capstan and multiple takeup unit.

• *ASBESTOS INSULATING SYSTEMS*

Carded asbestos is applied to continuous single conductor as an integrated operation with saturating, rotary forming, drying, cooling and polishing of the finished wire. Wire from No. 20 gauge to No. 6 AWG is handled through an asbestos wall thickness range of from .008″ to .040″ thickness in a single pass.

• *RUBBER OR PLASTIC JACKETING SYSTEMS*

Rubber and thermoplastic jacketing compounds are continuously applied to electrical wire or cable by the extrusion method. High speed, constant tension letoff and takeup equipment, controlled cooling or continuous vulcanizing equipment are powered by synchronized range drives as complete, integrated wire handling systems. Extrusion machines of customer's choice are furnished.

• *GLASS & VARNISH COATING SYSTEMS*

Double layer of glass or cotton wrapping is applied to round, flat or square conductor. Two individual coatings of high temperature varnish are applied and the finish baked in a continuous operation. Units are complete from letoffs to takeup frames.

• *SELF TRAVERSING REEL CORD DRYERS*

These ingenious machines are used to remove hygroscopic moisture from fibers, braided or knitted flexible cable. These machines increase extrusion speeds, reduce blister scrap loss and improve diameter control. They are easily installed in existing extrusion line.

TECHNICAL INFORMATION ON ANY OF THESE PROCESSES UPON REQUEST

C. A. LITZLER CO., INC.

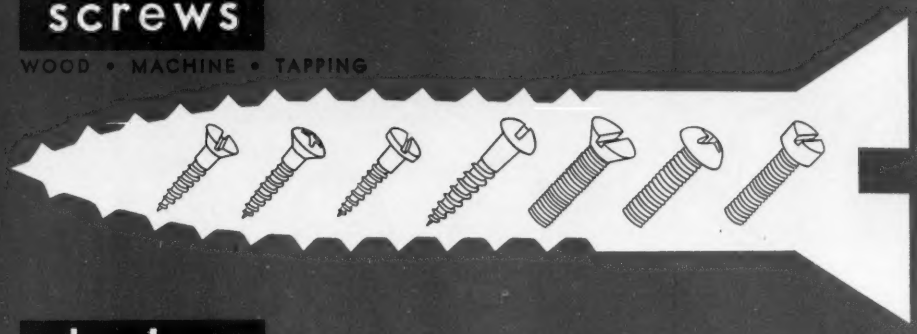
11621 DETROIT AVENUE
CLEVELAND 2, OHIO

cold heading?

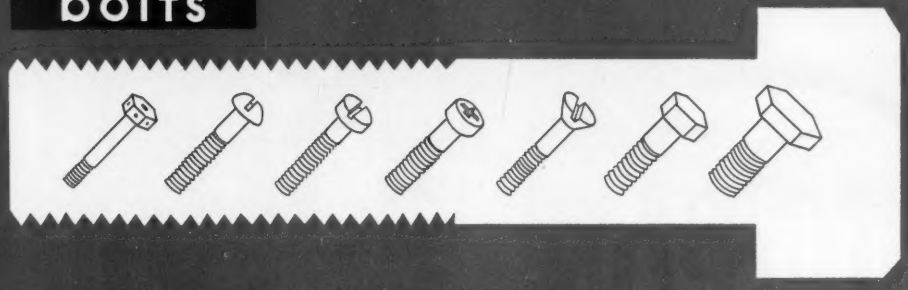
use NICHOLS NEVER-STAIN ALUMINUM WIRE

screws

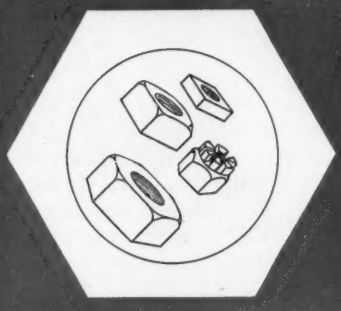
WOOD • MACHINE • TAPPING



bolts

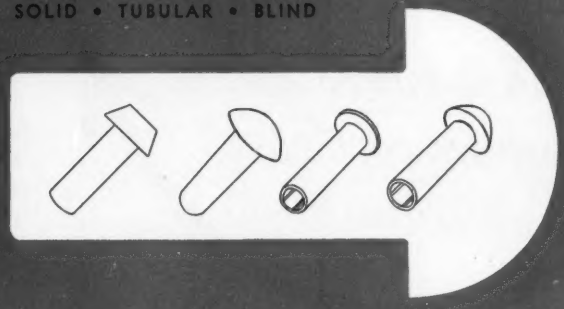


nuts



rivets

SOLID • TUBULAR • BLIND



Made to exact specifications for your particular requirements. Available in coils or in straightened and cut lengths in diameters to .4375" in all commercial alloys and tempers. Let us quote on Never-Stain Aluminum Wire "tailor-made" to your special needs. Excellent delivery.

Never-Stain Aluminum Wire for all other types of forming also available

NICHOLS WIRE & ALUMINUM CO.
Davenport, Iowa
One of the nation's leading producers of aluminum wire

DURPON*

WIRE-DRAWING COMPOUNDS

last twice as long...yet cost no more!

We realize we're claiming a lot for Nopco Durpons. Perhaps the only men who believe it are the men who use Durpons. But they are the ones that matter.

There are two sound reasons for Durpon's profitable performance: All Durpon compounds contain: (1) a buffer, to maintain the pH level, keep the emulsion from breaking; (2) a sequestering agent, which holds the metal particles away from the effective drawing ingredients, *keeps the bath clean.*

Won't you be the next to try these high-performance compounds, and learn first-hand the economies they bring? Write today for technical bulletin and free working sample.

Nopco Chemical Co.,
336 Industrial St., Harrison, N. J.

"Stay Stable Longer"

DURPON—for intermediate gauge wire
DURPON L—for heavy wire, rods, and tubes
DURPON FW—for fine wire

NOPCO

*Reg. U.S. Pat. Off.

PLANTS: Harrison, N. J. • Cedartown, Ga. • Richmond, Calif.

FAST SERVICE FOR STAINLESS STEEL IS CHASE'S SPECIALTY!

Twenty-five warehouses, four sales offices, stand ready to supply you the type, shape, size and quantity of stainless steel you need. You get the same kind of dependable service that has made Chase the nation's *headquarters* for brass and copper. Call Chase *today* for stainless steel!

Chase®

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WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass & Copper (†sales office only)

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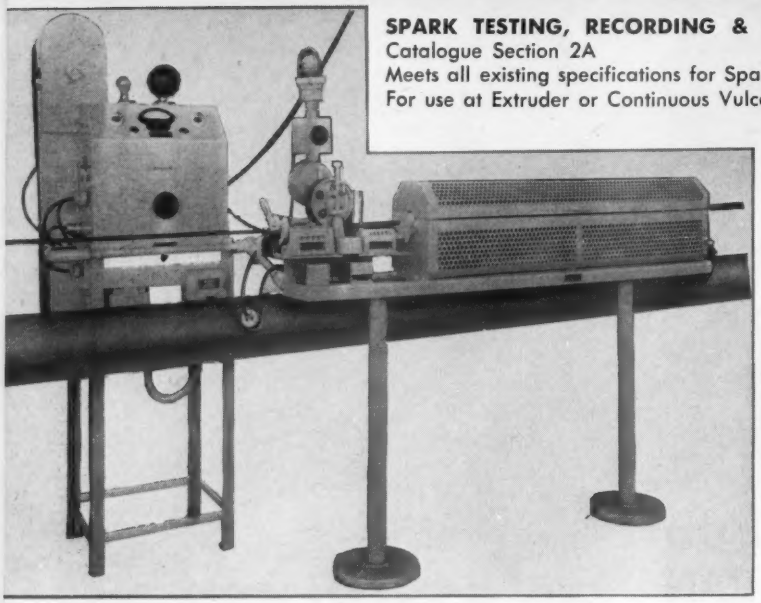
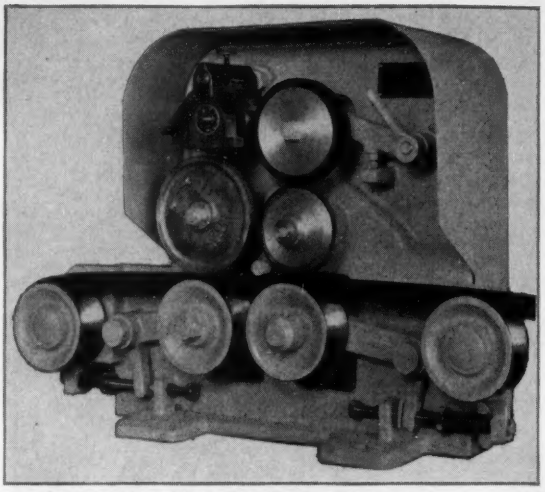
Atlanta	Cincinnati	Grand Rapids†	Louisville†	New York	St. Louis
Baltimore	Cleveland	Houston	Milwaukee	Philadelphia	San Francisco
Boston	Dallas	Indianapolis	Minneapolis	Pittsburgh	Seattle
Charlotte†	Denver	Kansas City, Mo.	Newark	Providence	Waterbury

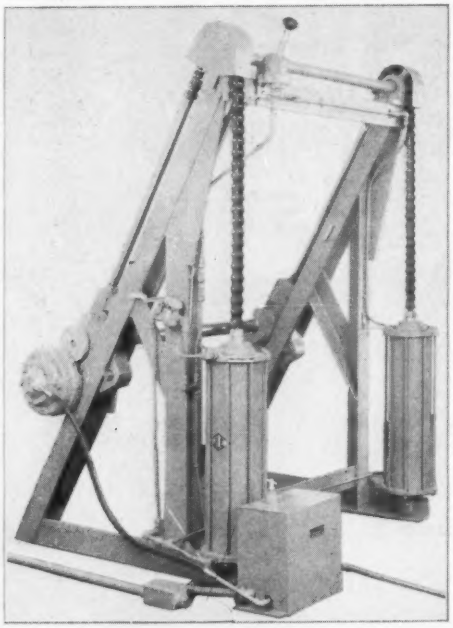
THE MARK OF QUALITY IN



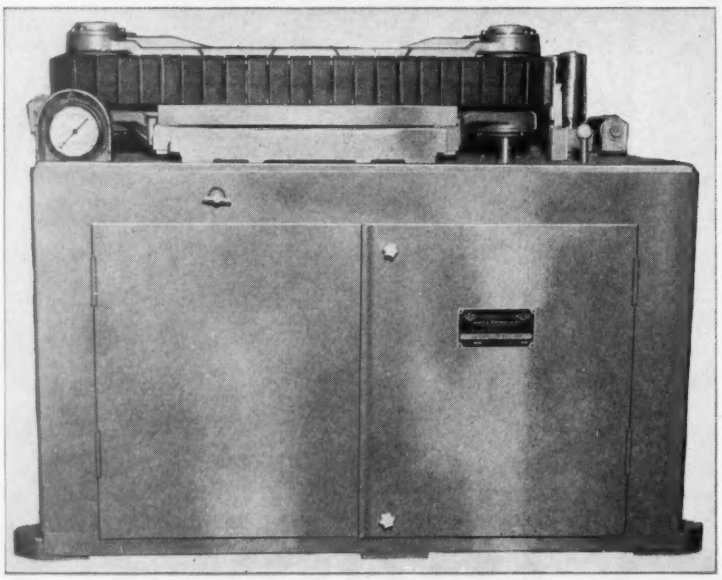
SPARK TESTING, RECORDING & MEASURING EQUIPMENT
Catalogue Section 2A
Meets all existing specifications for Spark Testing throughout the world.
For use at Extruder or Continuous Vulcanizer.



WIRE MARKING MACHINE, TYPE A-2
Catalogue Section 18
One of three types of Wire Marking Machines for use in re-reeling and spiral marking operations, also hot printing or striping at the Extruder.



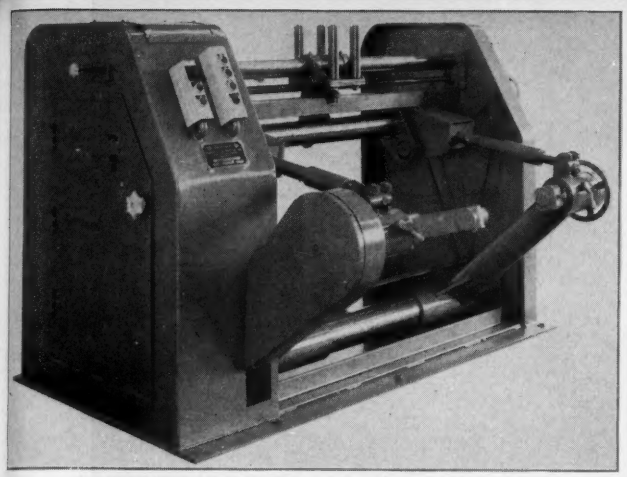
PAY-OFF STAND TYPE N48D8A
Catalogue Section 13A
A rugged, proven design, automatically raises and lowers reel by finger tip control, models available from 600# to 25,000# capacity.



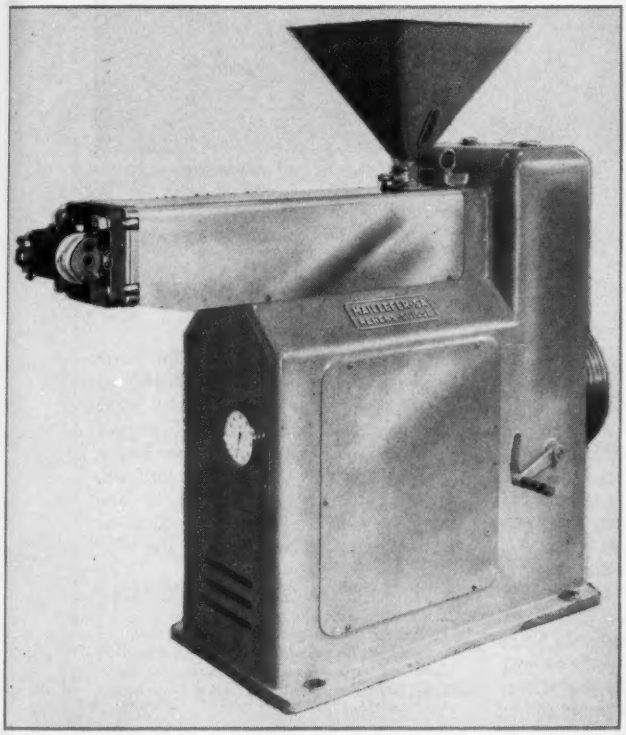
CATERPULLER, TYPE CHA — Catalogue Section 16A
An improved method of pulling cable, avoiding damaging or bending and eliminating capstan wheels. Pneumatically controlled.

JAMES L. ENTWISTLE CO.
PLANT and EXECUTIVE OFFICE:
1475 ELMWOOD AVE., CRANSTON (PROV. 7), R.I., U.S.A.

WIRE MACHINERY



SHAFTLESS TAKE-UP — Catalogue Section 3E
A modern unit of superior design that eliminates the use of Reel Shafts.



MAILLEFER EXTRUDER — Catalogue Section 9B
An efficient unit for the extrusion of plastics, nylon etc. Part of a complete Extrusion Line engineered to your requirements.

JLE

HERE ARE ILLUSTRATED A FEW OF THE MANY PROVEN MODELS OF JLE EQUIPMENT ENGINEERED TO THE REQUIREMENTS OF THE WIRE INDUSTRY, AND DESIGNED TO HELP SOLVE YOUR PRODUCTION PROBLEMS - - -

EXPERIENCE GAINED IN OVER 30 YEARS OF MEETING THE MACHINERY NEEDS OF LEADING WIRE MILLS IS REFLECTED IN THE QUALITY OF THE PRESENT JLE LINE. LET US PROVE TO YOU THAT JLE EQUIPMENT WILL DO YOUR JOB BETTER - - -

JLE **JAMES L. ENTWISTLE CO.** JLE

PLANT and EXECUTIVE OFFICE:
1475 ELMWOOD AVE., CRANSTON (PROV. 7), R.I., U.S.A.

For strength, economy and versatility, there's nothing to compare with steel wire. These sparkling bird cages will soon be homes for contented parakeets, canaries and other feathered pets. Advance Specialty Co., Inc., makes a wide range of formed wire products.

Steel Wire for the Birds

Making bird cages and other formed wire products calls for many different kinds of steel wire. At the Advance Specialty Company, Inc., Lansdowne, Pa., you can see a wide variety of wire forms on the production lines: bird cages (as shown above), fan guards, refrigerator shelves, oven and dishwasher racks, bread baskets, toy items, lamp guards, display racks, etc.

Turned out by the thousands at the Advance Specialty plant, each formed wire product has its specific requirements as to the type of wire. Some products are made from our bethanized wire, which has a tight, uniform coating of pure, sparkling zinc applied by our electrolytic process. Other products, made from bright wire, are welded and formed before being electro-plated. In supplying wire for these applications, our mills pay careful attention to such important details as temper, strength, uniform gage and surface finish.

Bethlehem makes just about every kind of steel wire. Some are general-purpose grades. Others are tailored to meet the requirements of such products as cold-headed screws, upholstery springs, bicycle spokes, lock washers, brush handles, mechanical springs, and armor wire for cables.

The steel wire that's best for your product is likely to be a grade and quality we're producing right now. You say the word, and we'll be glad to have a Bethlehem man give you prices, delivery and other details. Just put in a phone call to the nearest Bethlehem sales office or write to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

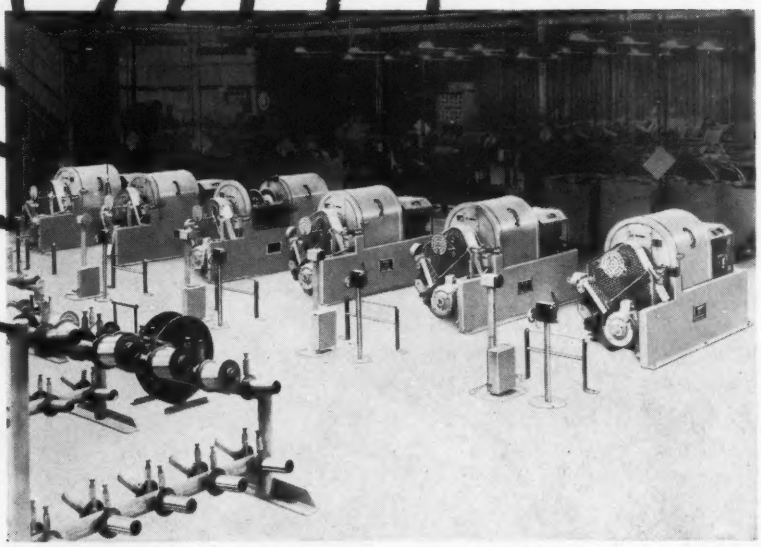
On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation.

BETHLEHEM STEEL

BETHLEHEM STEEL

. . . the ever-widening *Circle of Influence—of*

COOK BUNCHER-STRANDERS



Pictured, above, are (6) COOK BUNCHER-STRANDERS, Model BH-16 and Supply Stands, in operation at a large mid-eastern wire plant . . . producing the finest quality concentric wire.

THERE'S NO SUBSTITUTE FOR PERFORMANCE—NO SUBSTITUTE FOR QUALITY... *no substitute for success...*

and no substitute for **COOK BUNCHER-STRANDERS**

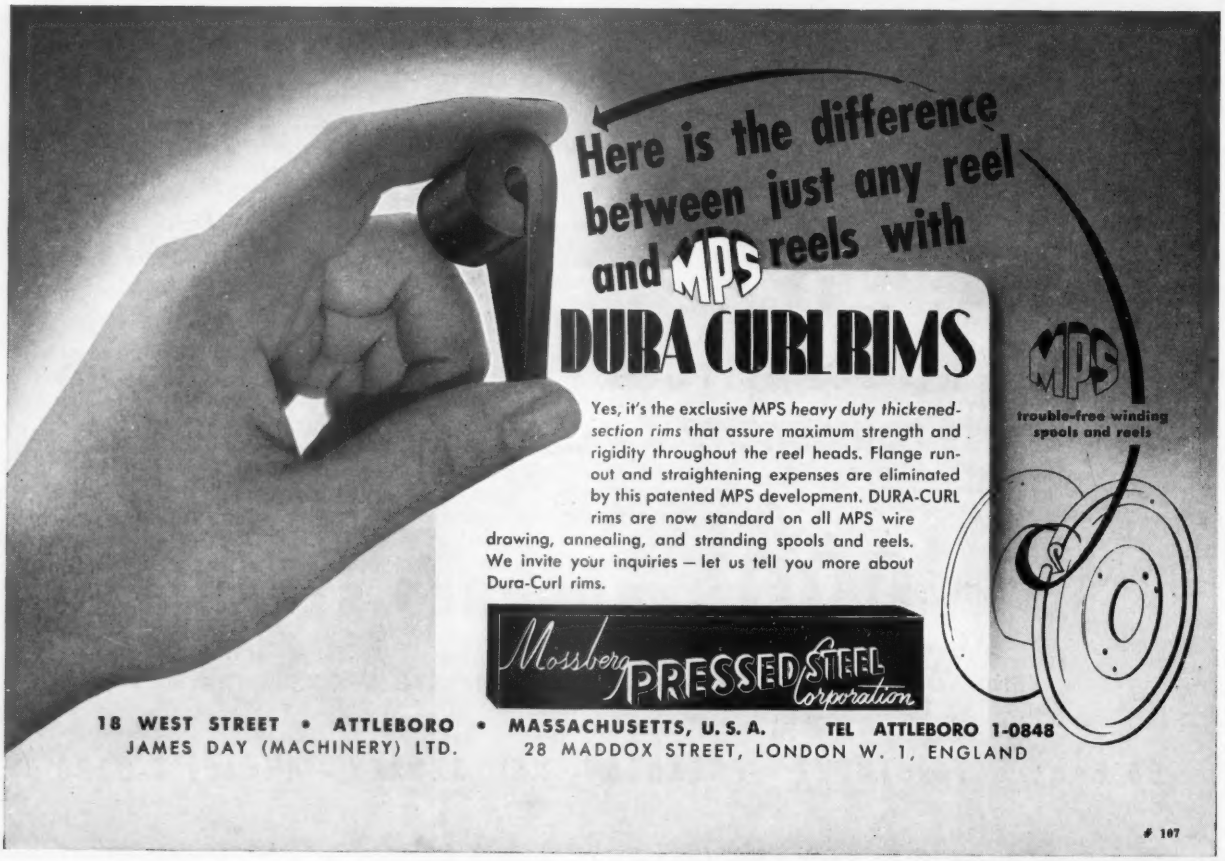
SEND FOR COLOR BROCHURE TODAY—COMPLETE SPECIFICATIONS

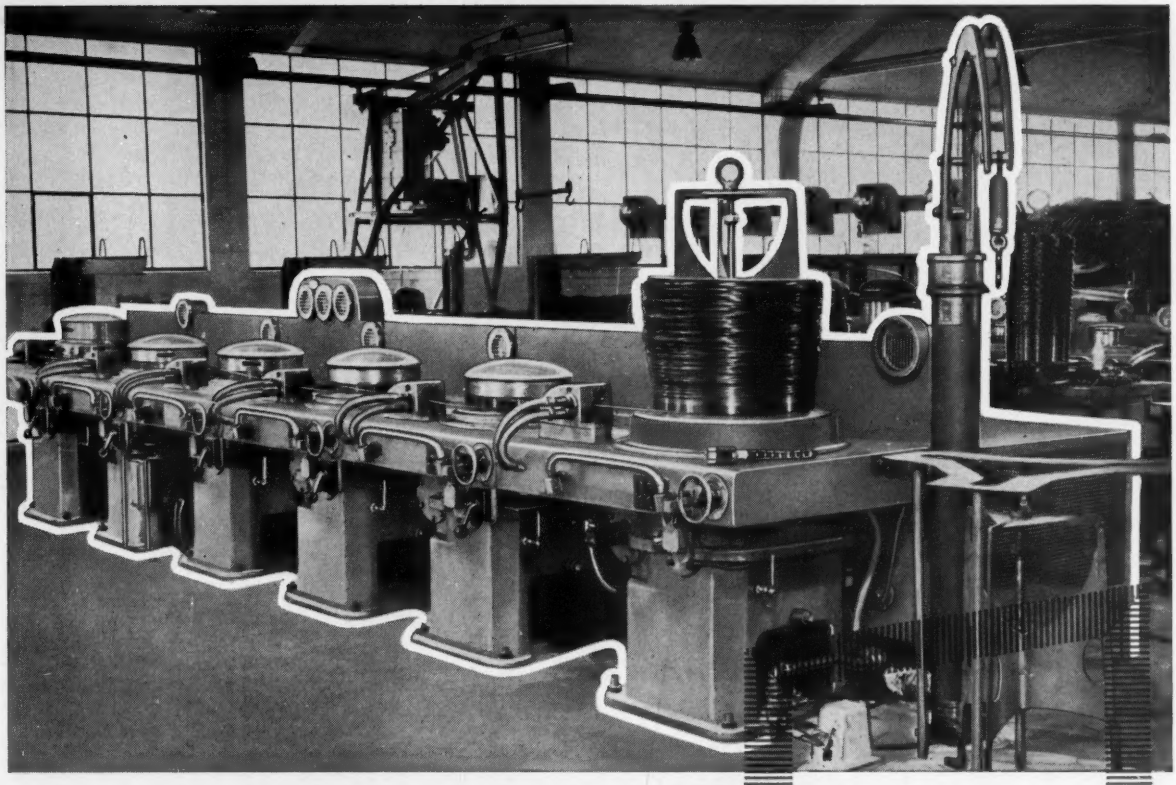
50 EAST 25TH STREET • PATERSON, NEW JERSEY • ARmory 4-6380

Welcome

TO MEMBERS AND GUESTS
ATTENDING THE
1955 WIRE CONVENTION

YOU TOO SHOULD USE
SUPERIOR MPS SPOOLS AND REELS
WITH THE EXCLUSIVE HEAVY DUTY
DURA CURL RIMS


Here is the difference
between just any reel
and MPS reels with
DURA CURL RIMS
Yes, it's the exclusive MPS heavy duty thickened-section rims that assure maximum strength and rigidity throughout the reel heads. Flange run-out and straightening expenses are eliminated by this patented MPS development. DURA-CURL rims are now standard on all MPS wire drawing, annealing, and stranding spools and reels. We invite your inquiries — let us tell you more about Dura-Curl rims.
MPS
trouble-free winding spools and reels
Mossberg PRESSED STEEL Corporation
18 WEST STREET • ATTLEBORO • MASSACHUSETTS, U. S. A. TEL ATTLEBORO 1-0848
JAMES DAY (MACHINERY) LTD. 28 MADDOX STREET, LONDON W. 1, ENGLAND
107



This picture shows a Beeline DG 4, built for an inlet wire diameter of about 7 mm (approx. 2 SWG). High carbon steel.

THE BEELINE WIRE DRAWING MACHINE

Straight-line type Wire Drawing Machine for high production of all wire grades

Prominent Beeline features:

- Complete absence of slipping between wire and block.
- Direct block-to-block wire running, with automatic speed control and no loops or other mechanical adjusting devices.
- Continuous speed adjustment from almost zero up to maximum.

Let us help you to solve your problems. We shall be glad to answer your questions promptly. Don't forget to let us know what wire is to be drawn, the inlet and finished diameter, its intended use, the production required, and all other relevant information (tensile strength of the finished wire etc.). Then we can suggest a machine that will be just right for you.

The machine is at present manufactured in three different sizes:

BEELINE DG 5
for heavy wire, about 13 mm. (7/0 SWG)

BEELINE DG 4
for wire rods, about 7 mm. (2 SWG)

BEELINE DG 3
for wire with an inlet diameter of about 3 mm. (11 SWG)

MH

MORGÅRDSHAMMAR

MORGÅRDSHAMMARS MEK VERKSTADS AB • MORGÅRDSHAMMAR • SWEDEN

Cables: Morgårdshammar, Ludvika. Tele: 0240–71100

THE MONTGOMERY COMPANY

ESTABLISHED 1871

25 CANAL STREET

WINDSOR LOCKS, CONNECTICUT

BARE ELECTRICAL TINSEL CONDUCTORS

in long lengths, ready for insulating with textile rubber or plastic.

For Cords Used On

Telephones — Radios — Electric Shavers — Hearing Aids.

Used Bare for Voice Coil Lead Wires on Loud Speakers

Electric Shaver Tinsel meets U/L Standards

Telephone Tinsel meets Military Specifications

SILVER COATED COPPER WIRE

To ASTM Specifications for UHF Cables and Hook-up Wire to Industry and Government Specifications.

TINSEL LAME (FLAT WIRE)

Silver and False Gold Coated Copper

also

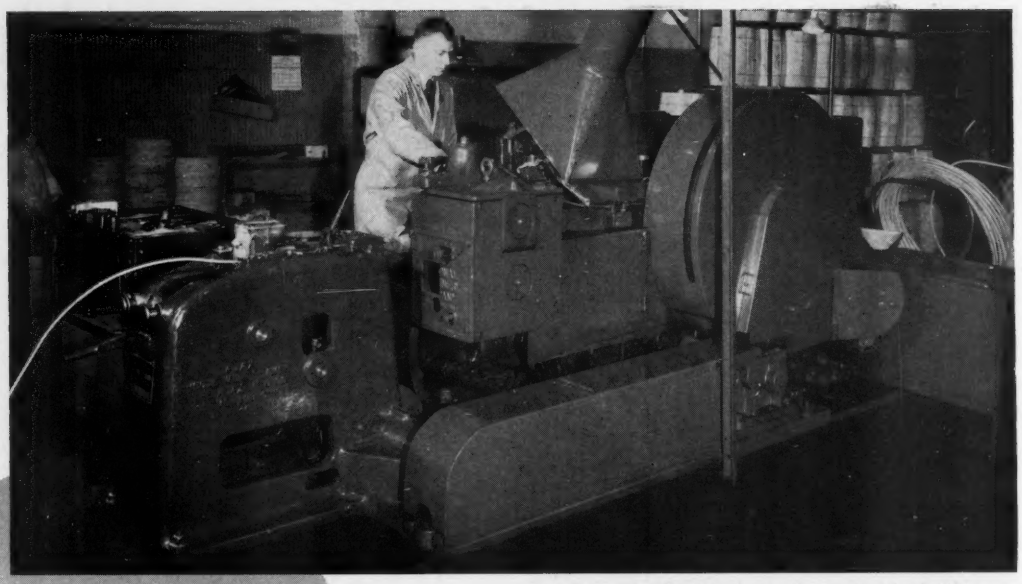
Aluminum Tinsel (Slit Foil)

Gold - Silver - Red - Green - Blue

for weavers of ribbons and garlands

"NEVA-TARN" GOLD & SILVER TARNISH PROOF YARNS

Plain, Supported or made into novelty yarns. For knitters and weavers of dress, upholstery, automotive and drapery fabrics.



Courtesy of Lake Erie Screw Corp., Cleveland, Ohio

If you have
COLD HEADERS
you need

Ajax-Hogue Wire Drawers

Here are the Advantages of Drawing Wire at your Headers

REDUCES COST OF MATERIAL Highest quality cold headed products from hot rolled stock instead of mill drawn wire.

HEADS EASIER Less tendency for split or cracked heads. Hogue-Drawn wire has a lower yield point.

WIRE ENTERS HEADER STRAIGHT and is not coiled after drawing.

UNIFORMLY ACCURATE SIZE on successive coils.

INCREASES DIE LIFE of heading dies.

CLEAN AND PERFECT COATING - no scratches or scuff.

CONTINUOUS DRAWING Rod ends may be welded together.

• *Write for Bulletin No. 111-A* •

THE MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
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DEWART BUILDING NEW LONDON, CONN.
W. P. WOOLDRIDGE CO., • BURLINGAME, CAL. • LOS ANGELES 22, CAL.

by **SYNTHETIC**

Synthetic yarns of Viscose Rayon, Acetate Rayon, High Tenacity Cordura, Nylon, Dacron, Orlon and Fortisan, together with Purified Cotton (manufactured under Western Electric License), furnished you on Single or Multiple Wound Braider or Serving Tubes, in Standard packages.

Special Twisting, featuring knotless packages, is also done. We can supply all yarns in constructions and in packages to meet your exact specifications.

Cotton yarns in all sizes.

DYED YARNS ARE OUR SPECIALTY

Synthetic and cotton yarns treated for electrical applications.

WAXED LACING CORDS CORE YARNS

In fact, any yarn requirement for electrical insulation is either carried in stock or can be processed for you in our up-to-the-minute manufacturing facilities.

Write today for information.

SYNTHETIC THREAD CORP.

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Bethlehem Telephone
UNiversity 8-8575

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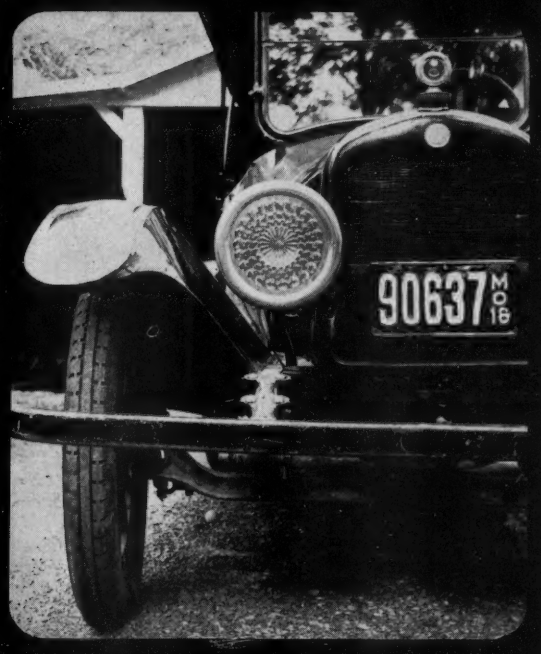
How long did it take...
to get from here... to here?



Answer: 27 years

Before electric headlights were introduced in 1913, night driving by feeble, undependable light was a hazardous venture. Further research led to the development of today's high-performance sealed beam lights which became standard equipment on 1940 cars.

At the same time, the rubber industry was developing new and better ways to make rubber work harder. Partner in this development is Monsanto with its group of high-performance rubber chemicals which have done—and are still doing—so much to improve tires and other rubber products.

For example, Monsanto Santocure was the original commercially produced sulfenamide type accelerator and with Santocure NS is considered a standard of the rubber industry. Santocure NS has similar behavior in compounded rubbers as Santocure, and is characterized by excellent delayed action which gives greater freedom from scorch. The amount of Santocure NS can generally be reduced about 10% because of its greater strength.

Write today, for your copy of catalog "Chemicals for the Rubber Industry," to MONSANTO CHEMICAL COMPANY, Rubber Chemicals Dept., 920 Brown Street, Akron 11, Ohio.

MONSANTO
CHEMICALS – PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

MONSANTO CHEMICALS FOR THE RUBBER INDUSTRY

ANTIOXIDANTS
Flectol* H
Santoflex* DD
Santoflex 75
Santoflex AW
Santowhite* Crystals
Santowhite MK
Santowhite L
Santowhite Powder

MERCAPTO ACCELERATORS
Santocure* NS
Santocure
El-Sixty*
Mertax (Purified Thiotax)
Thiotax* (2-Mercapto-benzothiazole)
Thiofide* (2,2'-dithiobis (benzothiazole))
Thiofide S (Seed Form)

ALDEHYDE AMINE ACCELERATORS
A-32
A-100

SPECIAL MATERIALS
Thiocarbanilide ("A-1")
Santovar*-A
Sulfasan* R
Insoluble Sulfur "60"

ULTRA ACCELERATORS FOR LATEX, ETC.
R-2 Crystals
RZ-50-A
RZ-50-B
Thiurad* (Tetramethyl-thiuram-disulfide)
Mono Thiurad (Tetramethyl-thiuram-monosulfide)
Ethyl Thiurad (Tetraethyl-thiuram-disulfide)

GUANIDINE ACCELERATORS
Diphenylguanidine (D.P.G.)
Guantal*

COLORS

REODORANTS

HIGH QUALITY

fiber glass yarns for wire and cable insulation

Pittsburgh Fiber Glass yarns are made of exceptionally uniform continuous filaments, twisted and plied for any desired buildup. They are packaged for use with all standard types of serving and braiding machinery.

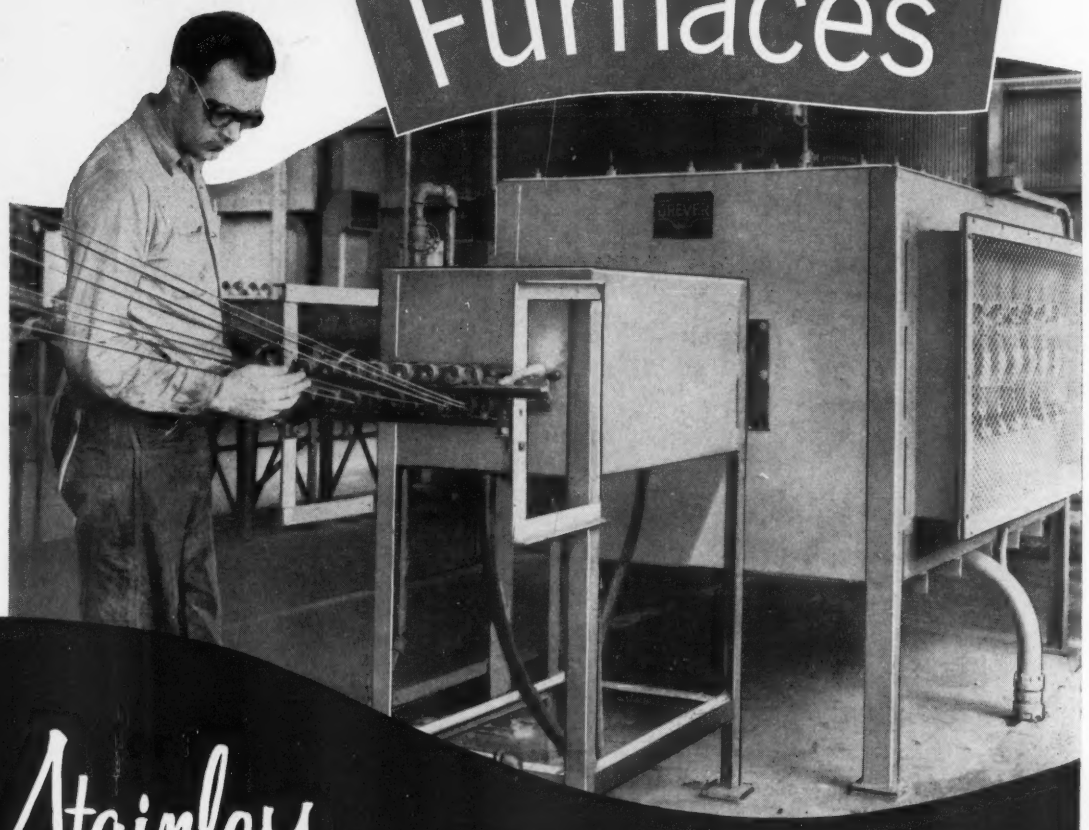
Pittsburgh yarns have proved their high quality with numerous manufacturers. If you have not yet put them to your tests, you are invited to make arrangements through our executive or district sales offices. Pittsburgh Plate Glass Company, Fiber Glass Division, One Gateway Center, Pittsburgh 22, Pennsylvania.

FIBER PG GLASS

PAINTS • GLASS • CHEMICALS • BRUSHES • PLASTICS

PITTSBURGH PLATE GLASS COMPANY

Wire Annealing Furnaces



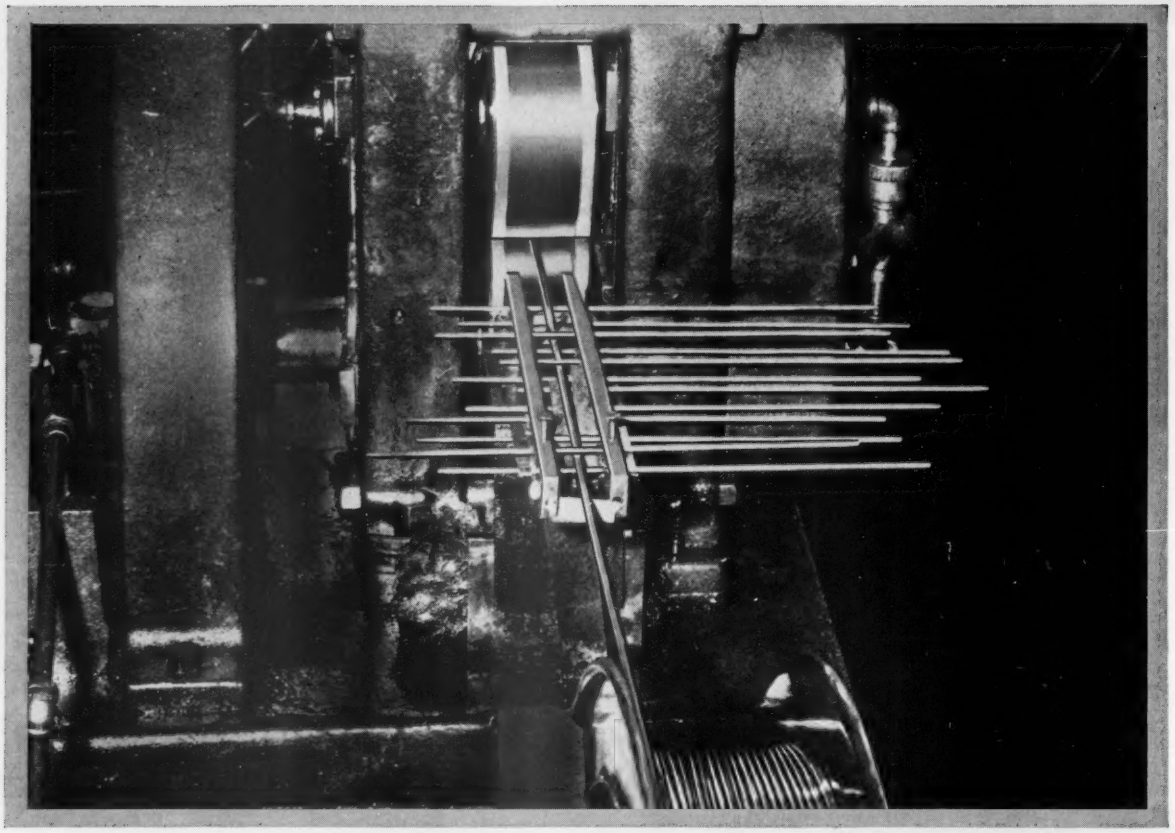
Stainless

Other wire furnaces continuously bright anneal all analyses and sizes of stainless as well as other alloy wires economically. Complete automatic temperature control either electric or gas fired.

Call on our staff of experienced furnace engineers to discuss your wire heat treating problems

DREVER CO.

RED LION RD. and PHILMONT AVE.
BETHAYRES, PA.



Carbide rolls flatten tough stainless steel...

More than a year on the same spot —and still producing perfect wire

After ten million revolutions – more than a year of continuous running on the same spot – these Carboloy® cemented carbide rolls at the Knowles Loom Reed Works, Inc., showed no signs of wear.

In contrast, the steel rolls formerly used for flattening stainless-steel wire into precision textile loom reeds required spot changes every two weeks.

The benefits this New Bedford, Mass., firm received from Carboloy cemented carbides did not end with improved roll life.

Manpower savings: Steel rolls expanded and contracted under the heat of the run, requiring a man on every machine to inspect reed tolerances. Because carbides were not affected by heat, one man now handles several machines, freeing manpower for other jobs. And, all machine downtime due to roll changes as well as roll refinishing was eliminated.

Quality improvements: Steel rolls mushed as they wore, crowning the wire and causing rejects. Carbides held uniform tolerances, and the rolls' lasting high-luster finish was imparted to the reeds, making them more marketable.

This Knowles case history of improved product quality, longer roll life, reduced manpower and maintenance costs, is typical of the benefits Carboloy cemented carbides are bringing to the wire industry.

Whether your business is flattening, drawing, extruding, or heading, there's a Carboloy product to fit your needs. For more information, or in-plant assistance from a Carboloy Wire Die Engineer, write today.

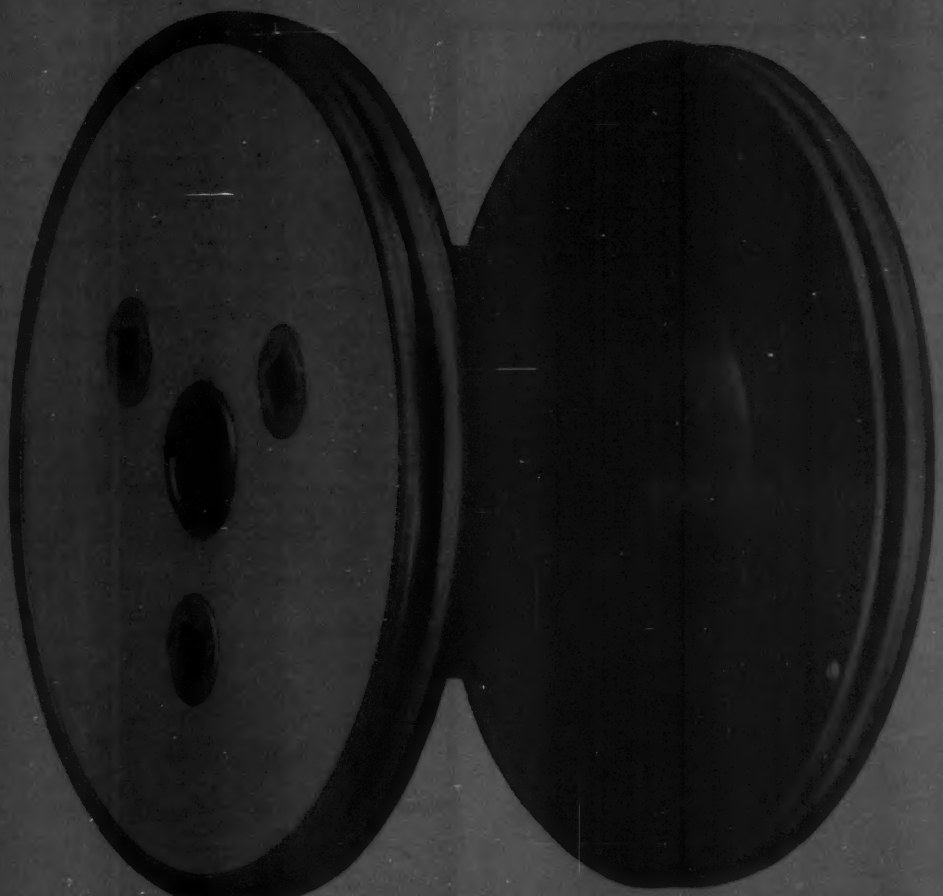
"Carboloy" is the trademark for products of the Carboloy Department of General Electric Company

CARBOLOY
DEPARTMENT OF GENERAL ELECTRIC COMPANY

11171 E. 8 Mile Ave., Detroit 32, Michigan

Carboloy Created-Metals for Industrial Progress

FOR REDUCED MAINTENANCE COST
USE THE REEL WITH THE
"PRESSURE PAD"* FASTENER

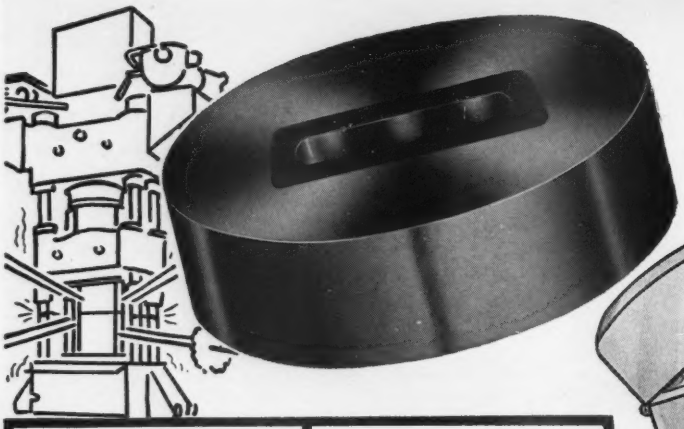


*PAT. NO. 2,609,162. TRADE MARK REGISTERED.

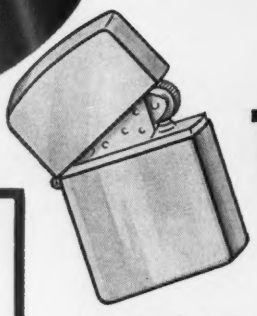
PHONE 2-3043

HOWSAM SPOOL COMPANY

500 RATHBONE AVENUE AURORA, ILLINOIS



12,979,660 LIGHTER CASES WITH TALIDE DIES

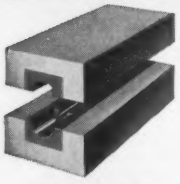


A leading producer of cigarette lighter cases was experiencing considerable trouble using steel dies. An excessive number of lighter cases were being scrapped due to tears and deformation. Die cost was running $.028 per lighter. Operation involves drawing .020" thick carbon steel on A-3 Niagara presses, 45 strokes per minute.

Our die engineers were called in, and after installing specially designed Talide dies on customer's press line, rejects were eliminated, as well as time previously spent in buffing and polishing the cases after drawing. Subsequent plating expense was reduced ⅓ due to the smoother surface on the cases drawn.

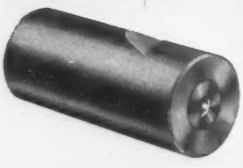
The original 15 Talide dies placed in production have now drawn a total of 12,979,660 cases for an average life of 865,310 per die. Previous steel dies produced an average of 15,000 cases per die. Die life was therefore increased 58-1 after the installation of Talide dies.

Die cost has now been reduced to $.0008 per lighter drawn, and customer estimates his saving for the past year, using Talide dies, has been at least $25,000.



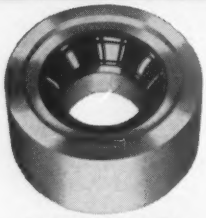
SWAGING DIES

Leading Fountain Pen Manufacturer cold swages 33 times more stainless steel parts with TALIDE dies.



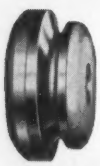
HEADING AND EXTRUSION DIES

Cold-heading ¾" carriage bolts, TALIDE dies produced 1,500,000 pieces, steel dies only 50,000.



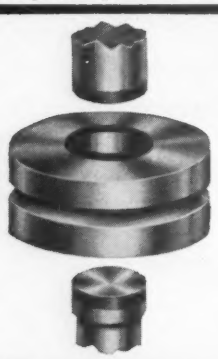
SHEET METAL DIES

137,000 hi-alloy steel Pressure Vessels drawn with TALIDE, against only 7,900 with steel dies previously used.



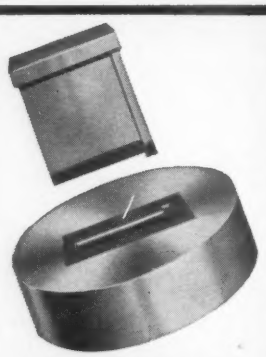
CURLING ROLLERS

TALIDE Curling Rolls last 65 times longer than steel rolls on beverage can forming operation.



POWDERED METALLURGY DIES

Pill dies of TALIDE metal outlast steel dies 100 to 1 while reducing rejects 82%.

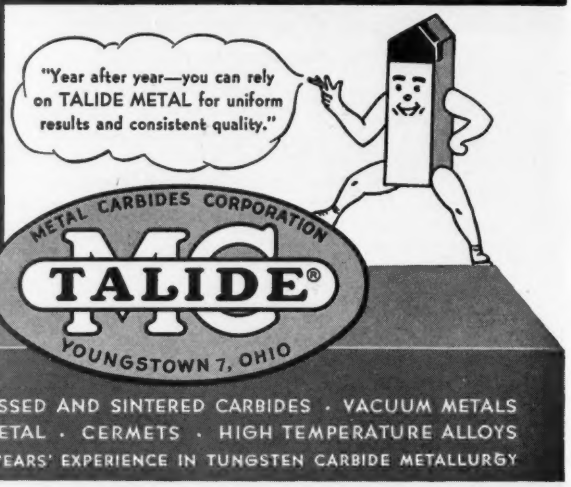


BLANKING AND FORMING DIES

70 times more paper discs blanked out with TALIDE—over hard alloy die.

IMPROVED QUALITY

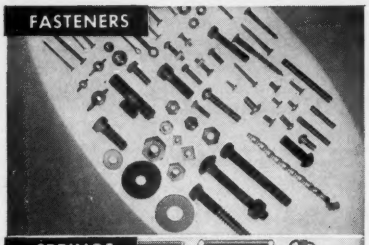
Additional refinements and improvements in our process have added still longer life to the wearing edges of Talide tools, dies and wear-resistant parts. The result is a carbide having a new, unique grain structure with harder and tougher properties than previous grades. Laboratory tests reveal our improved grades possess 25% greater strength and rigidity. Service life per grind up to 50% longer than previous grades has been proven in grueling field tests.

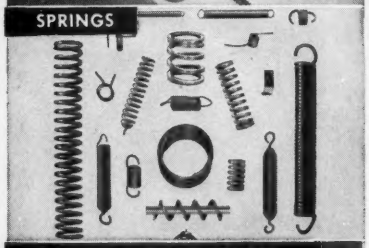

"Year after year—you can rely on TALIDE METAL for uniform results and consistent quality."
METAL CARBIDES CORPORATION
MC
TALIDE®
YOUNGSTOWN 7, OHIO
HOT PRESSED AND SINTERED CARBIDES · VACUUM METALS
HEAVY METAL · CERMETS · HIGH TEMPERATURE ALLOYS
OVER 25 YEARS' EXPERIENCE IN TUNGSTEN CARBIDE METALLURGY

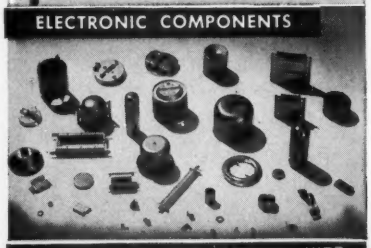
Send for new 84-page Catalog 55-G or ask for sales engineer to call.

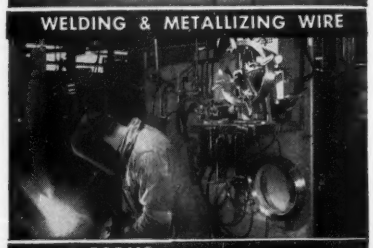
Basic Materials

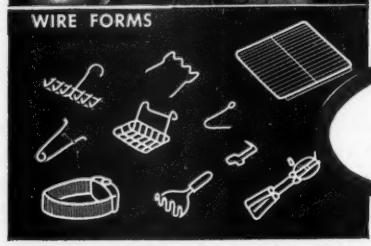
FOR A MILLION PRODUCTS











Alloy Wire, Rod and Strip . . .

Design Engineers are taking advantage of the outstanding mechanical and electrical properties and excellent formability of Alloy Wire, Rod and Strip. Results: Better products, smaller and lighter products, products that are more corrosion-resistant, more heat-resistant, more attractive —and more economical.

Alloy Metal Wire Division can supply you with high quality wire, rod and strip in Stainless Steels, Nickel Alloys and Electrical Resistance Alloys. Why not put these versatile materials to work for you?

SEND FOR FREE HANDBOOKS TODAY

FOR A BETTER DESIGN . . . *Use Wire, Rod, & Strip*

FOR BETTER PRODUCT PERFORMANCE . . . *Use Alloys*

Among the alloys we fabricate, you will surely find one with just the right combination of properties for your specific application. And you can profit from the fabrication advantages and material cost and weight savings of wire, rod and strip parts and assemblies. Select the alloy you need from these three functional groups:

STAINLESS STEELS—

Alloy Metal Wire Division can provide you with more than 20 different grades of stainless steels. These include the chromium-nickel Austenitic grades with their outstanding corrosion resistance and good mechanical properties; the high chromium Ferritic grades with their high heat resistance, corrosion resistance, and outstanding cold working properties; and the lower chromium Martensitic grades which can be heat treated to obtain exceptionally high strength and hardness in addition to good resistance to corrosion and high temperatures. Stainless steel Wire, Rod and Strip are used extensively for high strength and corrosion-resistant fasteners, springs and mechanical parts and for welding wire, woven and knitted wire parts, and many other applications.

NICKEL ALLOYS—

A wide variety of Nickel alloys are also available for hundreds of electrical and mechanical applications. The excellent electrical characteristics of nickel are especially advantageous for electronic tube parts, such as grids, cathodes, support rods and pins. Monel, because of its excellent corrosion resistance and good mechanical properties, is also used for many mechanical parts, fasteners and springs.

Inconel provides the valuable combination of outstanding heat resistance, corrosion resistance and high strength required in many applications.

RESISTANCE ALLOYS—

Five grades of electrical resistance alloys are now in production in wire, rod and strip form. These are: Alray A—20 Cr, 80Ni; Alray C—15 Cr, 62Ni, bal Fe; Alray D—18 Cr, 35Ni, bal Fe; Excelsior—45 Ni, 55 Cu; and Ni—Fe alloys.

These high quality alloys find extensive applications in the electrical and electronic fields.

SPECIAL WIRE SHAPES—

You can cut costs and improve product performance with Alloy Metal's Special Shaped Wire. Almost any cross-sectional shape can be made on our wire drawing equipment. These shapes can save you tons of metal and many hours of machining time. Shaped wire can be held to close tolerances and has a smooth, tough, flaw-free surface.

ALLOY METAL WIRE DIVISION

H. K. PORTER COMPANY, INC.

of Pittsburgh

PROSPECT PARK, PENNSYLVANIA

2

Important Announcement!

Federal Manufacturing Company has been licensed by the Continental Can Company to manufacture "PAYOFFPAK" equipment for the wire industry. In this connection FEDERAL has designed special wire drawing and packaging equipment, *with triple life carriers.*

We invite you to secure full information on this outstanding development that greatly increases the life and efficiency of this new method of drawing and packaging wire continuously. Write today.

★ ★ ★

OTHER *Federal Manufacturing Co.* PRODUCTS

Payoffs - Takeups - Capstans - Re-Spoolers - Patching Moulds
Measuring Machines

TESTING EQUIPMENT

FOR INSULATED WIRE

- ★ **Dielectric**
- ★ **High Potential**
- ★ **Continuity**

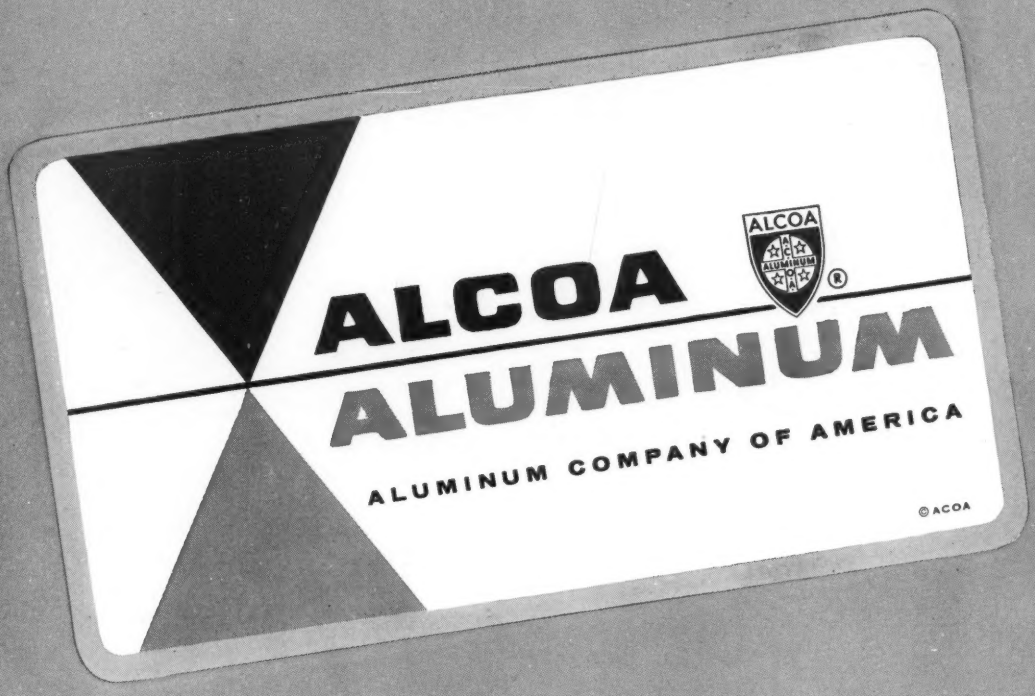
FOR ENAMELED WIRE

- ★ **Dielectric**
- ★ **Continuity**
- ★ **Abrasion Scrape**

THE FEDERAL MANUFACTURING CO. WALLINGFORD, CONN.

WIRE MACHINERY • TESTING EQUIPMENT

ALCOA ALUMINUM WIRE



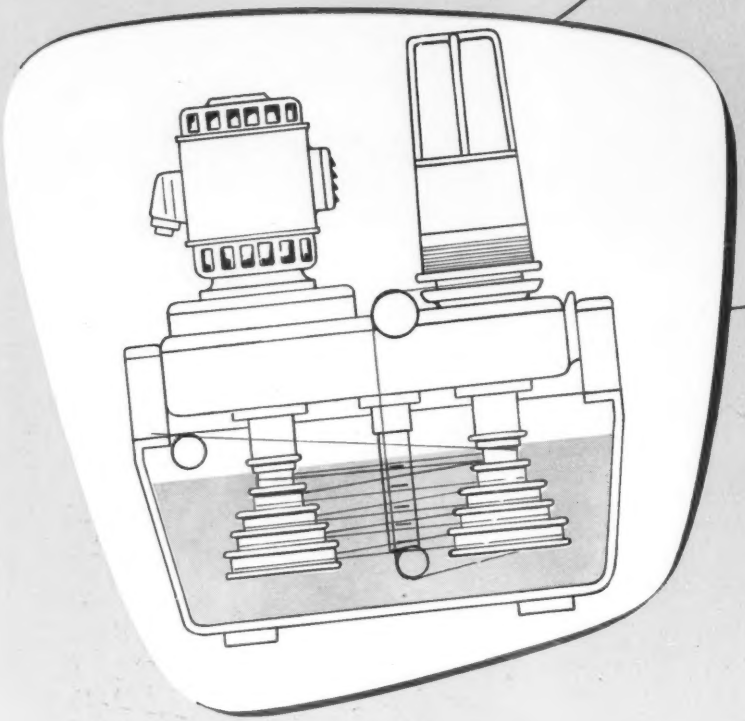
ALUMINUM COMPANY OF AMERICA

ALCOA BUILDING

PITTSBURGH 19, PA.

Success

in drawing wire depends to a great degree on the efficiency of the



COOLING SYSTEM

The best cooling system is one which places the entire drawing process into a drawing liquid which provides intensive cooling for the wire as well as the drawing dies.

The HERBORN multi-draft wire drawing machines operating under the submerged system offer this all-important advantage.

The high temperatures created at the speeds of modern wire drawing machines are highly injurious to the uniform quality of the wire as well as the life of the drawing dies. HERBORN wire drawing machines, operating under the submerged system, absorb these excessive temperatures quickly and safely through the drawing liquid which in turn is being cooled through a special cooling coil inside the tub so that the drawing liquid will maintain a constant temperature no matter how many hours the machine remains in continuous operation.

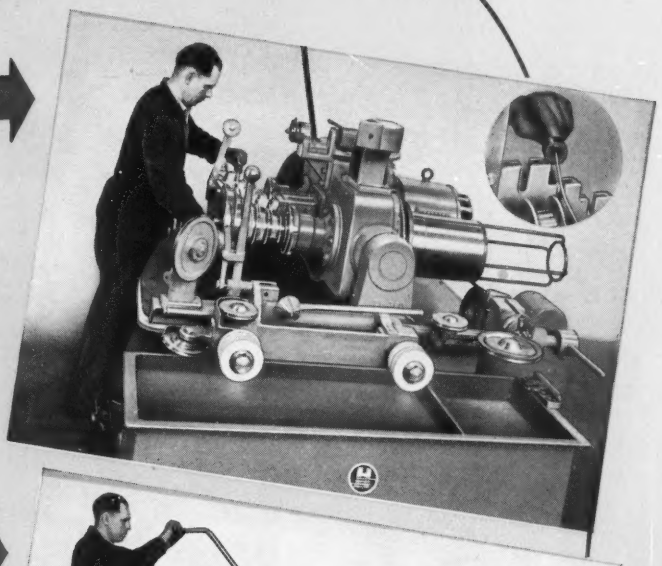
In addition, there are no pumps or separate containers to bring the cooling liquid back to normal temperatures since our HERBORN machines are completely self-contained units requiring only a continuous flow of cool water through the cooling coil to maintain safe and uniform temperatures in the drawing liquid.

The operation

of these machines is as simple as A, B, C:

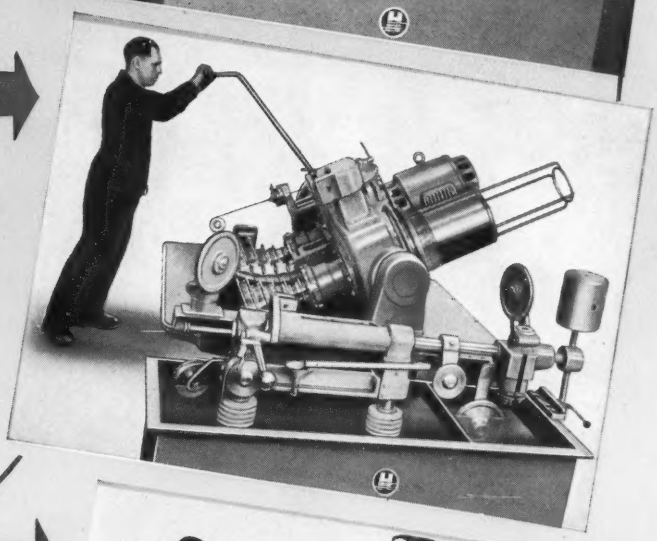
A)

The machine in string-up position. Note how easily and comfortably all working parts of the machine (dies, drawing rings etc.) are accessible to the operator.



B)

The machine being tilted into the drawing solution. Note how carefully the machine is balanced so that it will swing on its mainshaft with practically no effort at all on the part of the operator.



C)

The machine locked into drawing position, ready to operate.

These machines are suitable for the economic production of

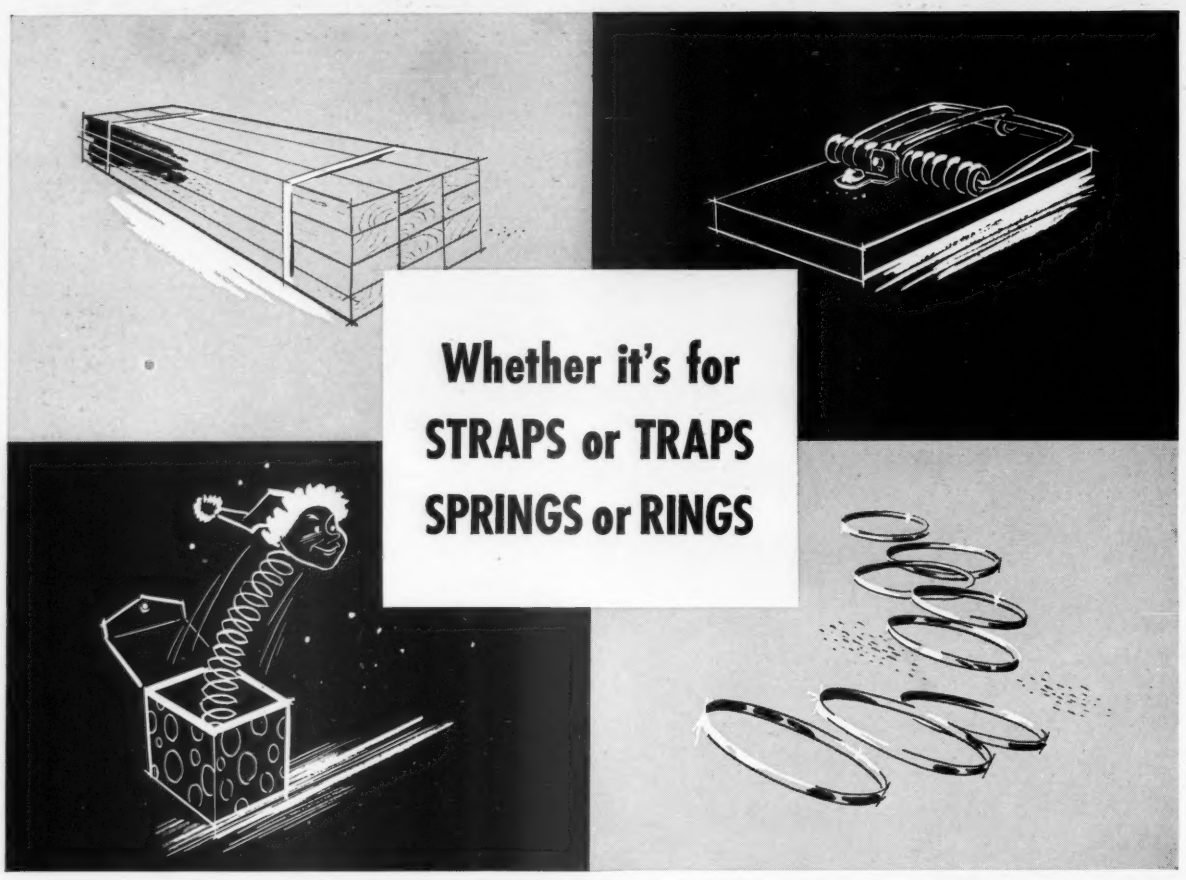
Iron Wire,
Steel Wire,
Copper Wire.

We solicit your inquiries and shall be glad to submit quotations.

MASCHINENFABRIK HERBORN BERKENHOFF & DREBES A.-G. **HERBORN/DILLKREIS** GERMANY

Sole Representative in the U. S. A.:

KURT ORBAN CO., Inc., 34 Exchange Place, JERSEY CITY 2, N. J.



SWIFT'S SOAPS are the efficient lubricants for wire drawing

Strategic distribution points throughout the U. S. and Canada can provide prompt, courteous service and immediate delivery on these versatile soaps:

SNAP. Heavy duty wire drawing powder. A neutral 96% soap affords consistently high titer range of 46 to 47° C. For use where exceptionally high temperatures prevail.

NO. 559 POWDER. In solution, will tend to remain fluid and completely free flowing at cool temperatures to afford top protection for wet drawing the finest wire products.

WHITE RIBBON (TALLOW) SOAP. For use at high temperatures where a low moisture, high soap content is desired.

Whether it's used to strap lumber or spring traps, all wire has this in common: speed is profit, but with the efficiency of speed comes the dangers of heat and friction. A compromise with the quality of your wire drawing lubricant at today's pace is a *certain* compromise with the efficiency you purchased in high speed equipment.

Swift's wire drawing lubricants are *efficient* because they are produced from *first choice* raw materials—to standards established through 50 years of serving specific wire drawing needs.

Why not let your Swift's man show you how our expanding line of soaps can help *you* make the most of speed . . . the *least* of heat and stress? Call him today and remember . . .

ONE TRIAL IS BETTER THAN A THOUSAND CLAIMS

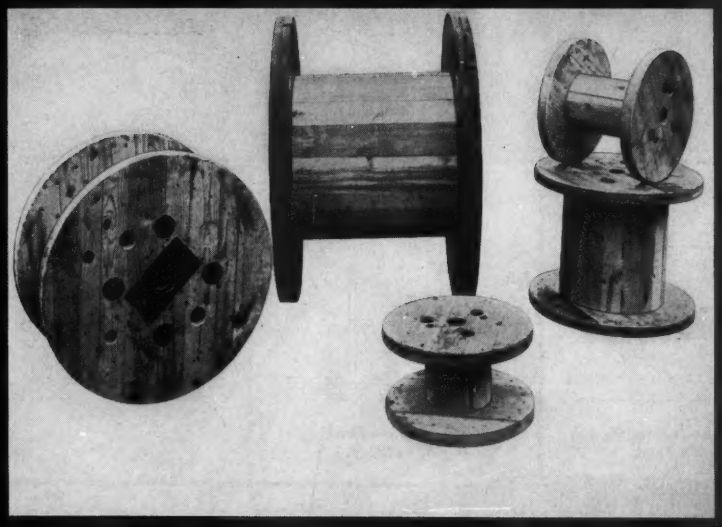
Swift
1855 CENTENNIAL 1955
TO SERVE YOUR INDUSTRY BETTER

SWIFT & COMPANY

SOAP DEPARTMENT

4115 PACKERS AVENUE • CHICAGO 9, ILLINOIS

use
NON-RETURNABLE
wood
reels
for
all
sizes
and
types
of
electric
wire
and
cable



SHIP the modern way!

LOOK! at the ADVANTAGES

- *REDUCED REEL INVESTMENT*
- *LESS STORAGE SPACE REQ'D.*
- *LOWER FREIGHT COSTS*
- *NO BOOKKEEPING*
- *NO REPAIR COSTS*
- *NO CASH DEPOSITS REQ'D.*
- *NO RETURN FREIGHT COSTS*
- *NO MORE HEADACHES!!!*

NON-RETURNABLE REELS GIVE YOU A DEFINITE PACKAGING COST

HIGH SPEED

SHIPPING SERVICE in our . . . OWN TRUCKS

within a radius of 200 miles from the plant. Fast freight will bring you Bridge reels in 5 days or less east of the Mississippi.

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MANUFACTURING COMPANY
HAZARDVILLE, CONNECTICUT

Telephone . . .
Thompsonville, Connecticut
Riverview 9-8308

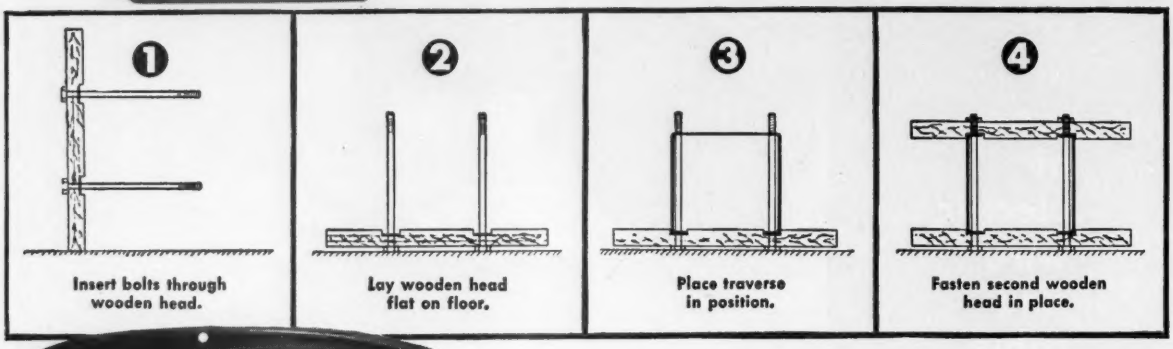
"REEL GOOD . . .

Let us quote on your reel needs. Send your specifications. Better yet, visit our plant and see how and why our reels are made so well at so low a cost.

WOOD REELS"

SAVE

TIME • LABOR • SPACE • MONEY through this simple 4-STEP ASSEMBLY of Republic Flanged Steel Traverses



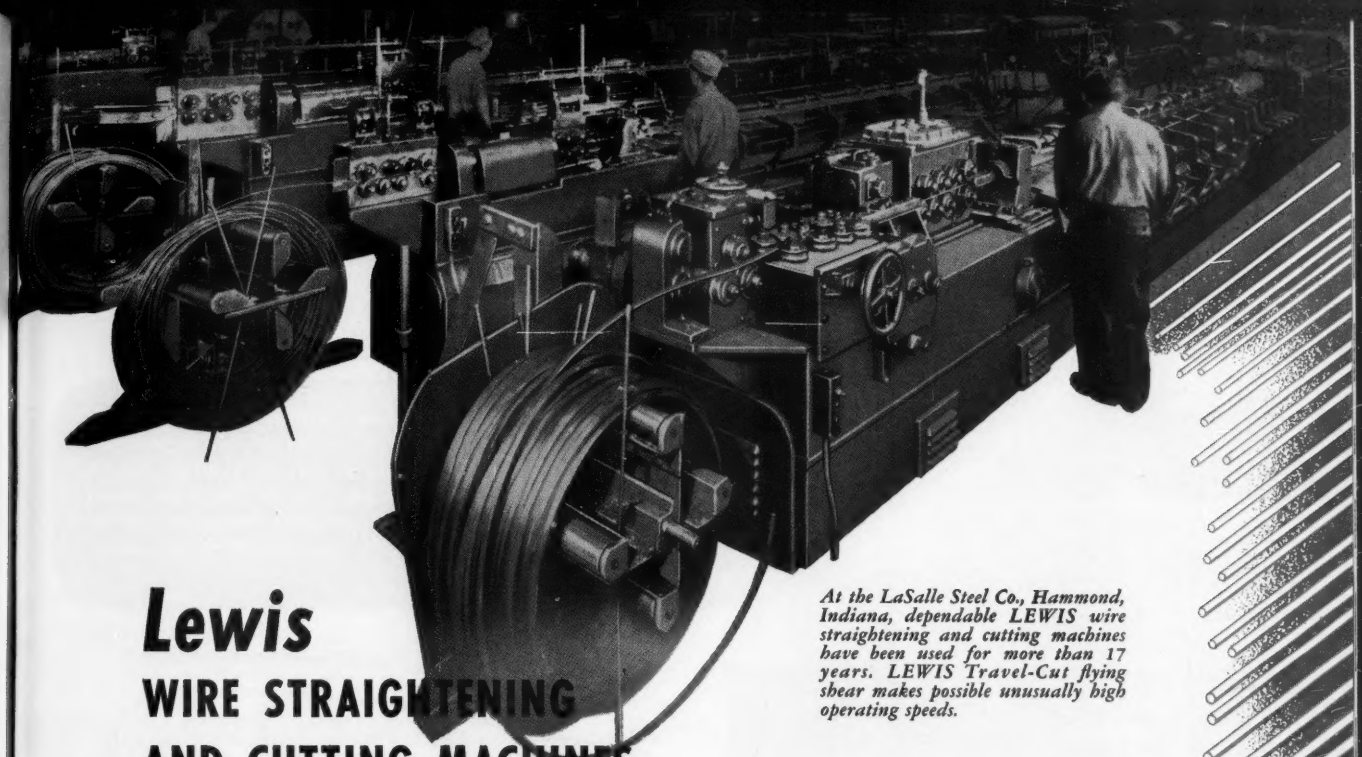
Republic Flanged Steel Traverses save time . . . because they require only four simple steps in reel assembly. They save labor . . . no special tools are necessary. They may be stacked and stored in a minimum amount of room . . . thus saving space. And they save money by providing long service life. Actual experience records show that Republic Flanged Steel Traverses have given as much as sixteen years' service—without refinishing or major maintenance. In many cases, their use has doubled the number of trips per reel before cut downs or scrapping of wooden heads.

Republic "Reinforced Type" Steel Traverses have extra strength where it is needed most—at bolt holes and base of flange. Reinforcing makes possible the use of lighter gauge steel, saving up to 20% in weight while increasing over-all length.

Sizes of Republic Flanged Steel Traverses range up to 56″ diameter and 48″ traverse. Finishes include plain, painted and hot dip galvanized. Width of flange and number of bolt and drain holes can be furnished to your specifications. Write today for prices.

REPUBLIC STEEL CORPORATION
Pressed Steel Division
6102 TRUSCON AVENUE • CLEVELAND 27, OHIO
Export Dept.: Chrysler Building, New York 17, New York

REPUBLIC
FLANGED STEEL TRAVERSES



At the LaSalle Steel Co., Hammond, Indiana, dependable LEWIS wire straightening and cutting machines have been used for more than 17 years. LEWIS Travel-Cut flying shear makes possible unusually high operating speeds.

Lewis
WIRE STRAIGHTENING AND CUTTING MACHINES

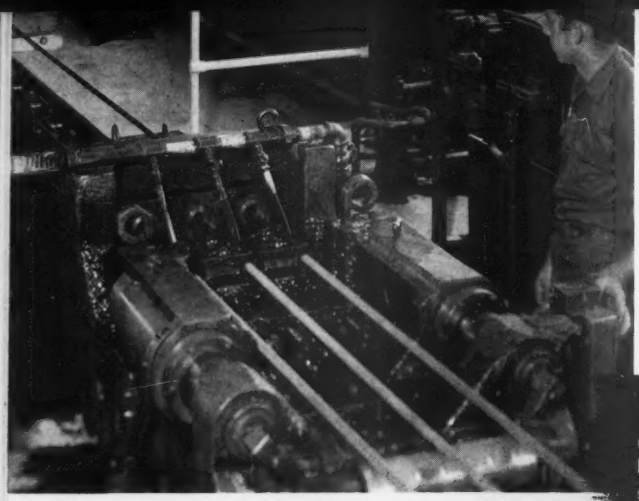
...preferred by leading manufacturers and suppliers of wire and wire products for continuous high-speed production

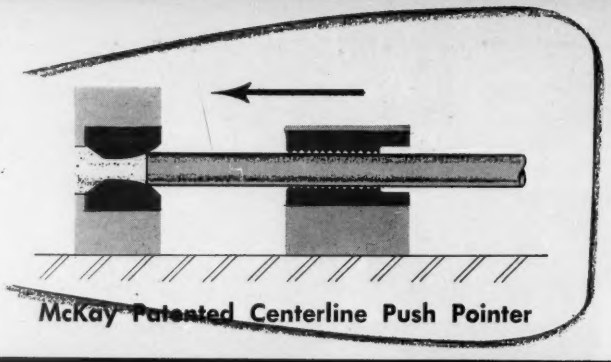
Companies like *LaSalle Steel* build their business on a reputation for top-quality products and prompt service. That is why LEWIS wire straightening and cutting machines have been preferred by leading manufacturers and suppliers of wire and wire products for over 40 years. LEWIS offers a *complete* line of machines for every production requirement — 23 models for wire from .012″ to 3/4″. Famous LEWIS *Travel-Cut* flying shear makes possible continuous production of perfectly straightened and cut wire at unusually high operating speeds. Many other time-tested exclusive LEWIS features make the LEWIS line of wire straightening and cutting machines unequalled for high speed, low cost wire and wire products production.

Write, wire or call today for information on LEWIS wire straightening and cutting machines for wire from .012″ to 3/4″, including the LEWIS Travel-Cut for continuous high-speed production

THE LEWIS MACHINE CO.

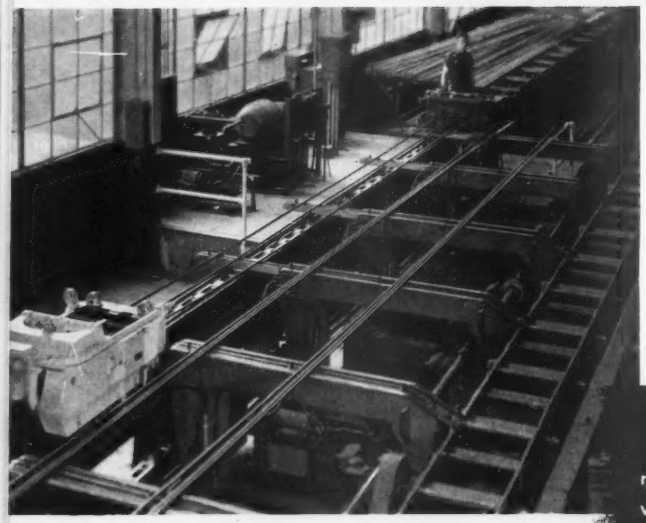
3447 EAST 76th STREET
CLEVELAND 27, OHIO

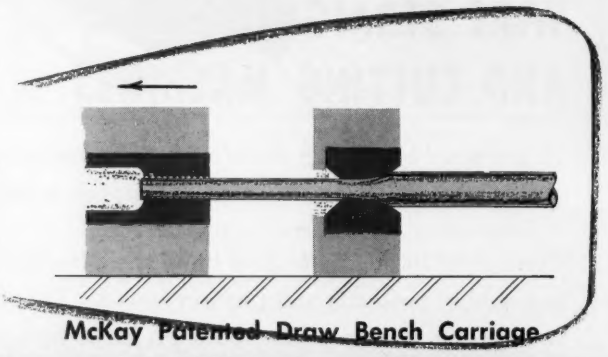




McKay Patented Centerline Push Pointer

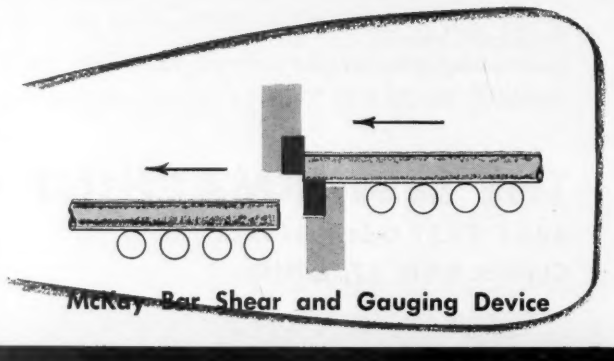
Automatic push pointing is the first operation in an automated draw line. The grips in the hydraulic push pointer engage the bars and push them through the dies so that the ends protrude a sufficient amount to accommodate the grips in the draw bench carriage. The pusher grips then automatically disengage and return to normal rest position while the bars are being drawn (as shown above).





McKay Patented Draw Bench Carriage

Positive, automatic, mechanical gripping combined with smooth, rapid acceleration of the carriage to maximum draw speeds along with automatic grip release and special high-speed carriage return drive insures perfect draws and continuous trouble-free production.

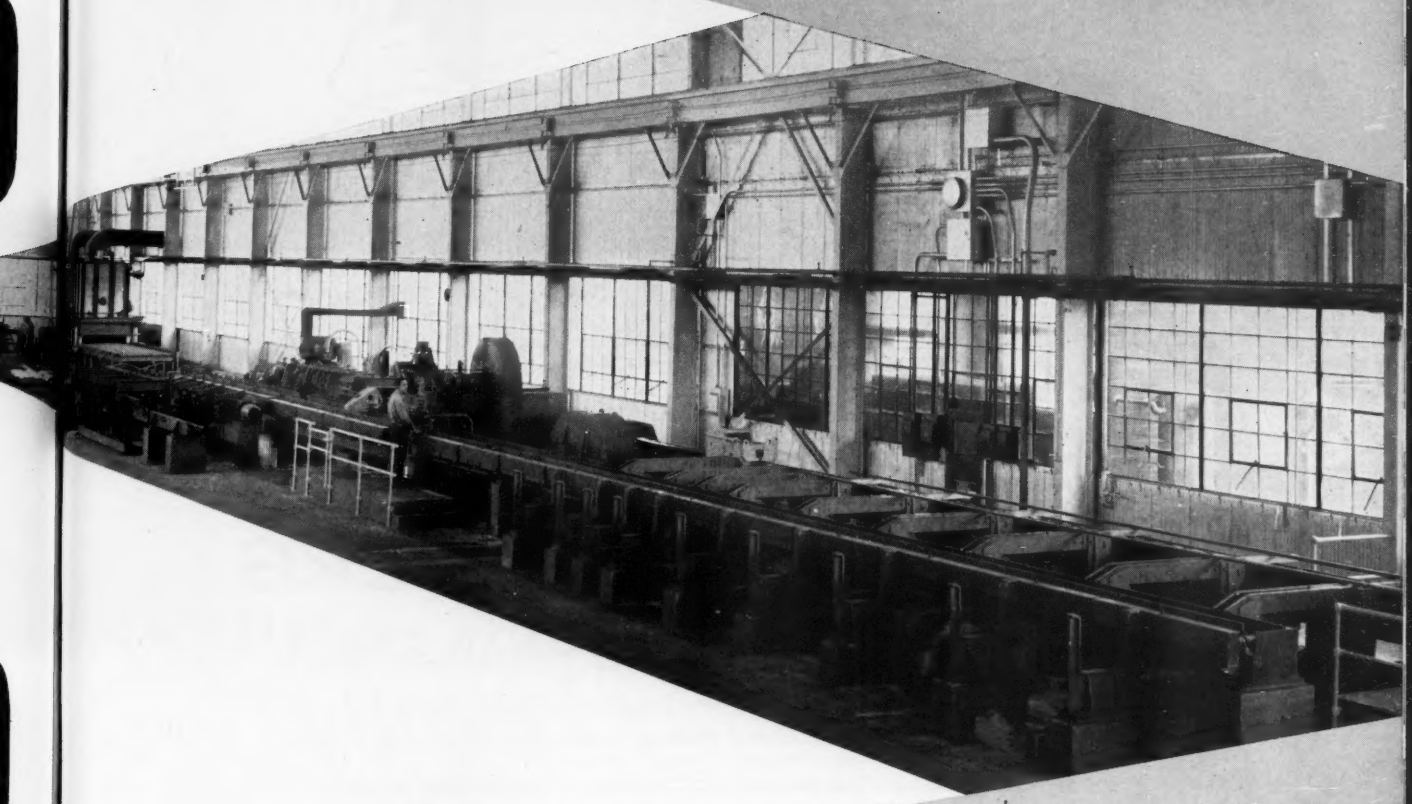


McKay Bar Shear and Gauging Device

A bar shear of rugged construction, incorporating a crop shearing device for multiple cuts and an automatic gauging table with driven conveyor rolls, accommodates maximum production schedules.

Round bars are automatically fed into a rotary straightener in continuous operation. Shapes are conveyed to shape straighteners where they are entered manually.

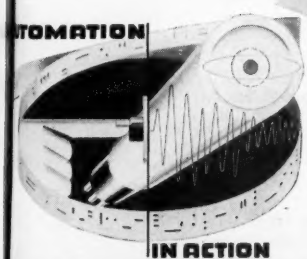
McKAY means SPEED and EFFICIENCY in COLD DRAWING



1. McKay Automated Lines boost production...

2. ...eliminate intermediate handling...

3. ...give uniform production.



The McKAY MACHINE Company
YOUNGSTOWN, OHIO

McK

ENGINEERS AND DESIGNERS OF
EQUIPMENT FOR THE AUTOMOTIVE,
FABRICATING AND STEEL INDUSTRII

No matter how you look at it...

APCO MOSSBERG

is the best deal in reels!!

Experience — Over 50 years of engineering and producing every conceivable type and size of steel spool, reel and bobbin for the wire industry.

Facilities—The spacious Apco Mossberg plant is equipped to produce standard or special types for you at the drop of a blueprint!

Service — Our engineering and service departments are at your beck and call. We will be happy to help you work out any problems that you may have involving the use of steel spools, reels and bobbins.

Write for our booklet containing information on

- Flat Head Spools
- Curled Flange Spools
- Stranding Reels
- Take Off Reels
- High Speed Wire Drawing Reels
- Vulcanizing and Insulating Reels
- Pressed Steel Bobbins For Wire Weaving

. . . or you name it and we'll make it!

(The original Frank Mossberg Co.)

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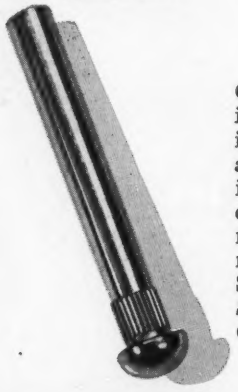
CHECK THE ADVANTAGES OF STAINLESS STEEL FASTENERS

✓for boosting product quality!

Where appearance and performance call for quality parts, don't overlook the advantages of stainless steel fasteners. Take the illustrated E. W. Ferry fasteners, for example. They're priced right in line with quality fasteners of other materials. Yet they offer all the extra qualities stainless steel brings to any part — high tensile strength . . . attractive, rust-resisting finish . . . and remarkable resistance to heat and corrosion. In almost any application they outlast, many times over, fasteners of nonresistant or plated metal. They cut maintenance costs, too. For even after years of service, disassembling rust-free stainless fasteners is always a fast, easy operation.

✓for reducing production costs!

The hardness of stainless steel fasteners results in substantial savings on the assembly line. Work is faster, results are better — simply because stainless screw-heads are less apt to burr and nick. This means major savings, for even a slipping screwdriver can seriously damage both the screw and the parts being assembled. Stainless steel fasteners cut tooling costs, too. For they are now available in practically every size and description.



Crucible now offers stainless fastener wire in all diameters . . . in suitable tempers . . . in a variety of finishes, including bright and several metallic and nonmetallic coatings . . . in all standard grades. For prompt delivery of the stainless steel wire you need — or for your free copy of Crucible's new, 32-page catalog "Rezistal Stainless Steel Wire" — call or write to *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

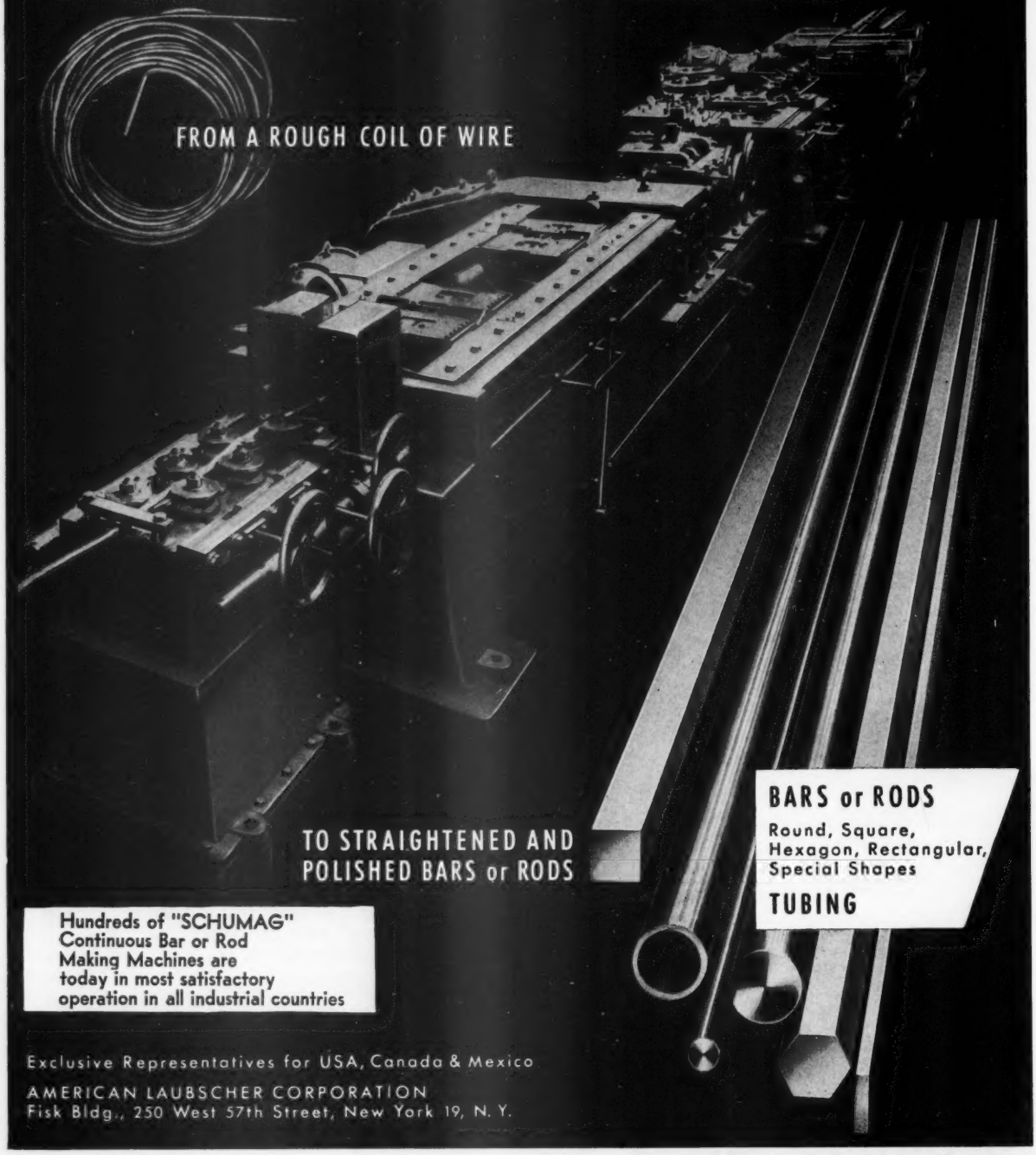
Crucible Steel Company of America

SCHUMAG AACHEN

GRAPHIK JUPP KUCKARTZ

THE FOUR-IN-ONE CONTINUOUS BAR and ROD MAKING MACHINES

FROM A ROUGH COIL OF WIRE

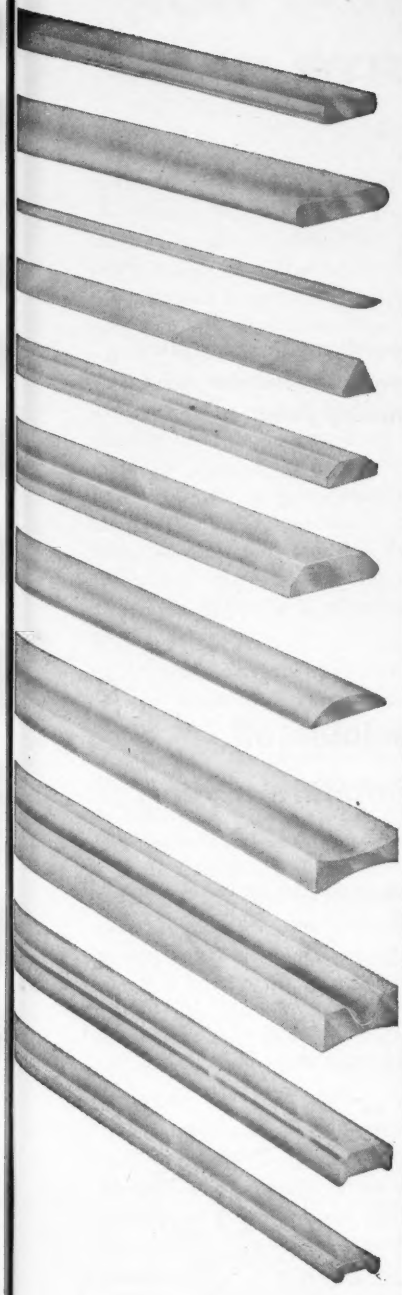


TO STRAIGHTENED AND POLISHED BARS or RODS

BARS or RODS
Round, Square,
Hexagon, Rectangular,
Special Shapes
TUBING

Hundreds of "SCHUMAG" Continuous Bar or Rod Making Machines are today in most satisfactory operation in all industrial countries

Exclusive Representatives for USA, Canada & Mexico
AMERICAN LAUBSCHER CORPORATION
Fisk Bldg., 250 West 57th Street, New York 19, N. Y.



NATIONAL WIRE

(COLD ROLLED)

in Coils or Straight Lengths

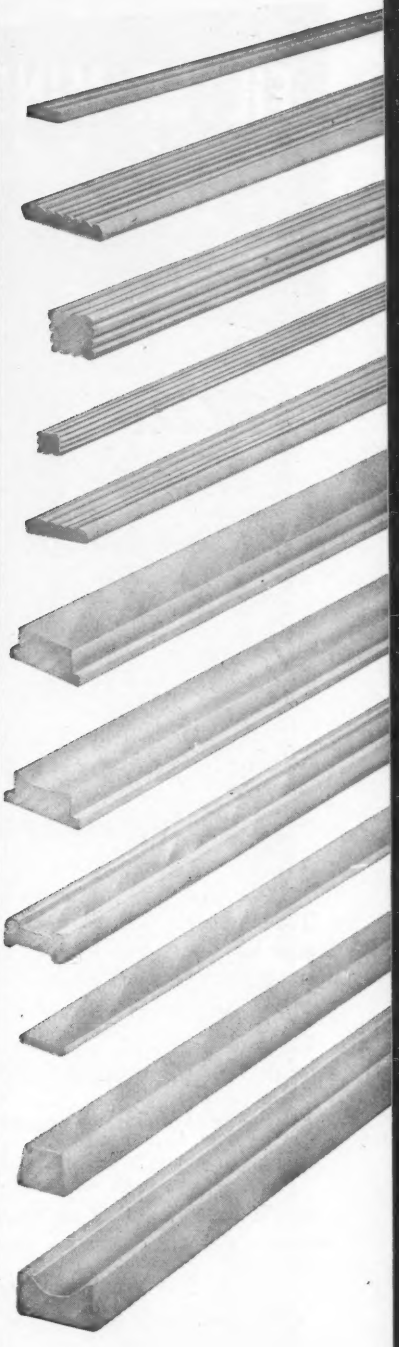
COMPLETE METALLURGICAL SERVICE

Manufacturers of

SPRING WASHERS	RETAINING RINGS
ROUND EDGE FLAT WIRE	KEYSTONE SHAPED WIRE
SQUARE EDGE FLAT WIRE	SPECIAL SHAPED WIRE

Shaped Wire in Coils or Straight Lengths, Ferrous or Non-Ferrous.

LARGE OR SMALL QUANTITIES



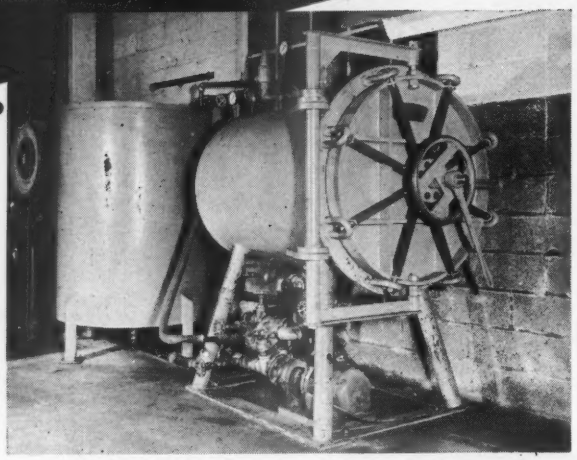
Manufactured by

THE NATIONAL LOCK WASHER COMPANY

PRECISION SHAPED WIRE DIVISION

NEWARK 5, N. J. MILWAUKEE 2, WIS. U.S.A.

FILTER MINERAL OIL
for die lubrication
AND
Make These Savings



Hercules Filter installation in prominent wire drawing plant.

The use of filtered mineral oil in place of soluble oil is saving many wire drawing firms thousands of dollars a year.

The soluble oils formerly used caused a build-up of fats in the equipment, clogging of jets, formation of rust, and frequent interruptions of production for cleaning purposes.

These disadvantages are eliminated when you use filtered mineral oils.

- Substantial dollar savings are effected.
- The oil does not have to be changed.
- The body of filtered oil remains in the same condition as when new—not for months but for several years. Only slight additions are needed.
- Die life is increased 50% or more. In one plant 21,000 pounds of .064 - .013 wire was drawn when Hercules filtered mineral oil was used as against 6,000 pounds of similar wire with unfiltered oil. Wire can be drawn at higher speed—i.e. up to 4500 to 5000 ft./min. for aluminum.
- Also, it is possible to substitute up to 50% of carbide dies in place of diamond dies.
- Use of filtered oil eliminates possibility of clogged oil passages which frequently cause burned dies.

SEND COUPON BELOW for Paper delivered before the Wire Association in New York City on April 29, 1955, which gives complete data on the economy and effects of using filtered mineral oil for the lubrication of wire drawing machines.

HERCULES FILTER CORPORATION
Hawthorne, N. J.

Send me copy of report with data regarding savings effected through the use of Hercules filtered mineral in wire drawing.

Name .....

Company .....

Street .....

City ..... Zone ..... State .....

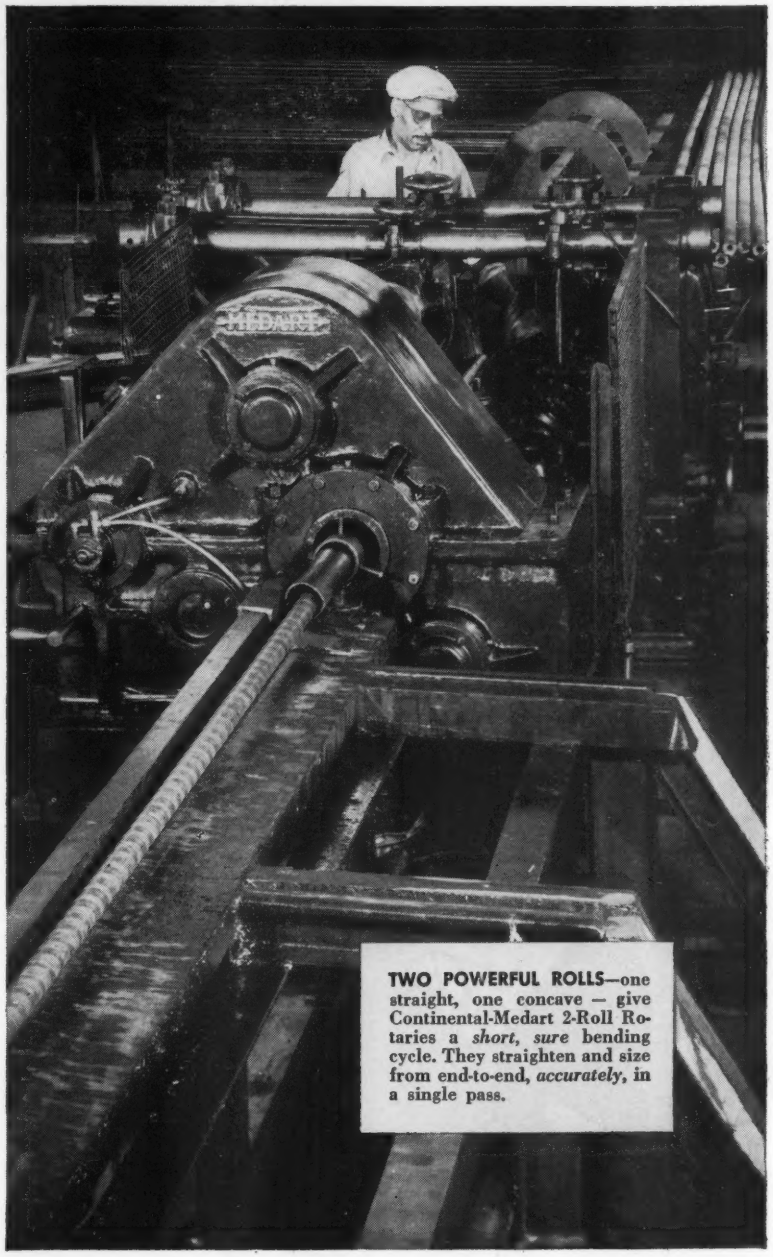
HERCULES FILTER
CORPORATION
191 Ethyl Avenue
Hawthorne, New Jersey

HOW Crucible Steel Company KEEPS BAR STRAIGHTENING COSTS DOWN

THESE rugged Continental-Medart 2-Roll Rotary Straighteners straighten accurately *from end to end*... simultaneously polish the bars and improve out-of-roundness . . . all in *just one pass.* As a result, Crucible Steel Company, Pittsburgh, Pennsylvania, is able to keep down the cost of straightening quality hot-rolled bars. They have virtually eliminated expensive rehandling and reprocessing. And they get complete automatic operation—bars are fed to and delivered from the machine mechanically. Only one operator is required for each machine.

If you want to save money, follow Crucible's example. Use Continental-Medart Straighteners. Use the 2-roll, single motor machine for straightening and sizing hot-rolled bars, or for sizing or polishing centerless turned bars. Use a Continental-Medart 2 x 2 Universal (two rolls, each driven by a separate motor) to straighten cold-drawn or centerless ground bars at high speed. Use a Continental-Medart Multicycle Straightener (with six rolls and *two cycles* of straightening) to straighten round pipe or tubing at very high speed.

Whatever your straightening requirements, call on Continental-Medart for rugged, dependable equipment and for expert engineering assistance. Continental-Medart manufactures a complete line of cold finishing equipment for processing everything from rough billets to fine wire.



TWO POWERFUL ROLLS—one straight, one concave — give Continental-Medart 2-Roll Rotaries a *short, sure* bending cycle. They straighten and size from end-to-end, *accurately*, in a single pass.

CONTINENTAL Foundry & Machine Company

CONTINENTAL-MEDART

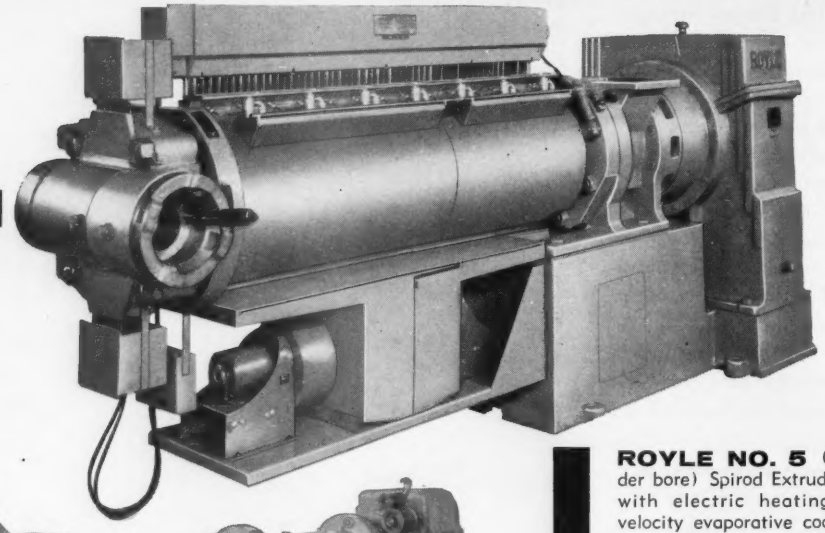
Engineering and Sales Offices: 200 Grant St., Pittsburgh 19, Pa.
General Offices: 4407 Railroad Ave., East Chicago, Ind.
Plants at East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
Copes-Vulcan Division, Erie, Pa.

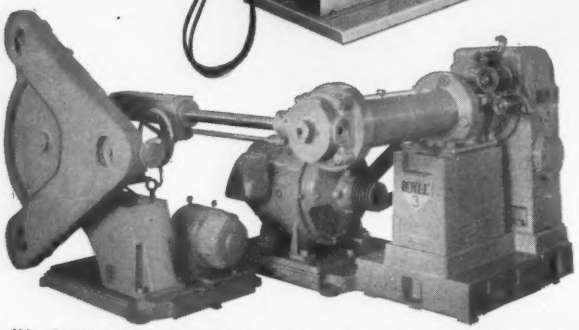
ROYLE

EXTRUDING MACHINES

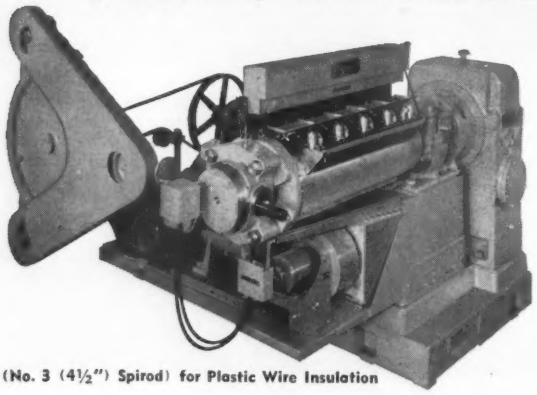
SPIROYLE - - - CIRCULATING HEATING AND COOLING

SPIROD - - - ELECTRIC HEATING · EVAPORATIVE COOLING





(No. 3 (4½") Spiroyle) for Room Temperature Continuous Vulcanizing



(No. 3 (4½") Spirod) for Plastic Wire Insulation

ROYLE NO. 5 (8½" cylinder bore) Spirod Extruding Machine with electric heating and high velocity evaporative cooling. An all purpose extruding machine for processing rubber and plastics. Available in sizes 1⅛" through 12" cylinder bore.

ROYLE SPIROYLE Extruding Machines are designed for the processing of compounds where the use of a circulating medium for sensitive operating temperatures is anticipated.

ROYLE SPIROD Extruding Machines for processes requiring higher, accurately zoned operating temperatures. Outstanding performance assured by the inclusion of a proportioning controlled system of high velocity evaporative cooling combined with tubular resistance heating.

All Spirod and Spiroyle cylinders are enclosed in a metal clad insulating jacket for increased efficiency and lowered operating cost.

Available in sizes 1½" through 12" cylinder bore.

SEND FOR BULLETIN 463

JOHN ROYLE & SONS

ROYLE PATERSON N. J. 1880

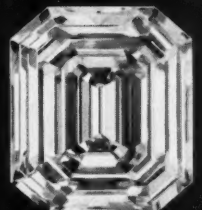
PIONEERED THE CONTINUOUS EXTRUSION PROCESS IN

London, England	Home Office	Akron, Ohio	Los Angeles, Cal.	Tokyo, Japan
James Day (Machinery) Ltd.	V. M. Hovey J. W. VanRiper	J. C. Clinefelter	H. M. Royal, Inc.	Okura Trading Co., Ltd.
Hyde Park 2430 - 0456	SHerwood 2-8262	BLackstone 3-9222	LUdlow 9-3261	(56) 2130 - 2149

Here is perfection!

ROEBLING high carbon wire is unsurpassed for industry today. Roebling wire is absolutely true to specifications ... absolutely uniform in gauge and finish. Manufacturers who try Roebling wire once, become Roebling customers from then on.

You *pay* for the best when you buy high carbon wire. Make sure that you *get* it! Always specify Roebling. John A. Roebling's Sons Corporation, Trenton 2, N. J.



The Jonker, world's largest emerald-cut diamond.

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Subsidiary of The Colorado Fuel and Iron Corporation

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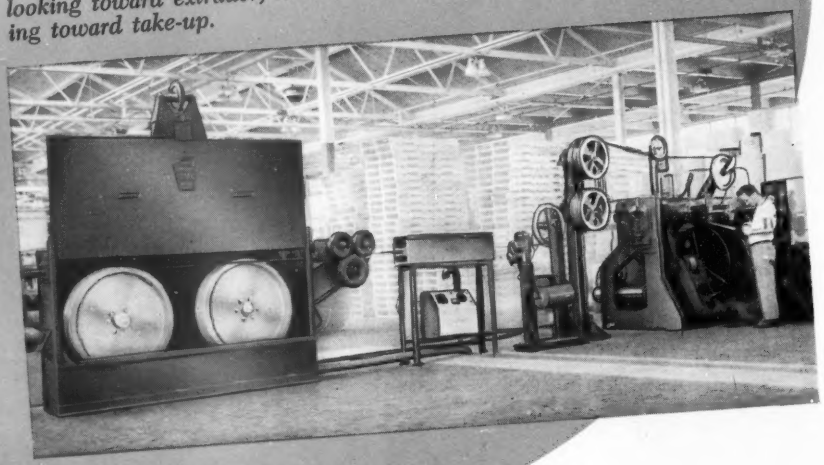
From Rome Cable Corporation . . .

"WITH INSTALLATION OF DAVIS-STANDARD EQUIPMENT, PRODUCTION IS UP, MAINTENANCE COSTS DOWN."

The units shown in these photos are part of a new Davis-Standard wire insulating line recently installed at Rome Cable Corporation. This equipment includes the latest of the special features that are constantly being added by Davis-Standard designers — features that, to Rome Cable, are "beneficial improvements."

New installation of Davis-Standard thermoplastic wire insulating line for Rome Cable Corporation, Rome, New York. Upper view looking toward extruder, lower view looking toward take-up.



Manufacturers in the expanding, highly-competitive wire industry cannot afford to invest in untried production equipment. Wire machinery, once installed, must produce. It must have the stamina to withstand the punishment of continuous operation at ever-increasing wire speeds. At the same time, the quality of its product must remain uniform without the need for wasteful tinkering. Finally, the name it bears must be its guarantee. That's why progressive wire manufacturers such as Rome Cable Corporation are turning more and more to Davis-Standard.

DAVIS-STANDARD
SALES CORPORATION
14 WATER STREET, MYSTIC, CONNECTICUT

SOLE SELLING AGENTS FOR . . . **THE STANDARD MACHINERY COMPANY,** World's Largest Manufacturers of Custom-Built Extruding Machines
IN EUROPE AND THE STERLING AREA, CONTACT FINNEY PRESSES LTD., BIRMINGHAM, ENGLAND

Sheffield KONE-PAK makes possible bigger loadings of wire for your machines (right). This means fewer stops for reloading—less time lost to idle machines.

How Sheffield's NEW KONE-PAK cuts wire-users' production costs...

A carload of manufacturers' or boxmakers' wire used to reach you in from *100* to *2000* coils depending on their size. Now you'll receive that same wire in just *50* compact KONE-PAKS. You'll save on handling and faster set-up for threading into machines. Sheffield's KONE-PAK will feed your machines bigger "meals"; you'll have fewer loadings and less dead time for setting up. You can see how your production savings will add up to real money!

Sheffield's KONE-PAK (patent applied for) is a stout, cone-shaped steel frame on which we spool the wire. The whole deal is mounted on a disposable wooden pallet and can be packaged in a super-strength cardboard container if desired.

Of course the best packaging is of secondary importance to what's inside. In this case it's the best wire of its kind that modern materials and methods can produce—quality-controlled every step of the way from Sheffield furnaces to finished product. Be sure you get Sheffield Wire—with the big plus of KONE-PAKaging.

a product of

SHEFFIELD STEEL
DIVISION
ARMCO STEEL CORPORATION
SHEFFIELD PLANTS: HOUSTON • KANSAS CITY • TULSA

A NEW SYSTEM *for* CABLE DIAMETER CONTROL

INDUSTRIAL GAUGES CORPORATION *announces...*

An original method of measuring and controlling diameter of insulated wire and cable *immediately beyond the extruder* — continuously and without contact.

The new equipment will cover the range of .400" to 3 inches.* It can be located between the extruder and trough on resin extruders and in the C. V. tube on rubber extruders.

A new principle of operation makes this gauge insensitive to fumes and "smoking" of the wire or cable being measured.

Electromechanical equipment for automatic control of capstan or screw speed is engineered to your extruder.

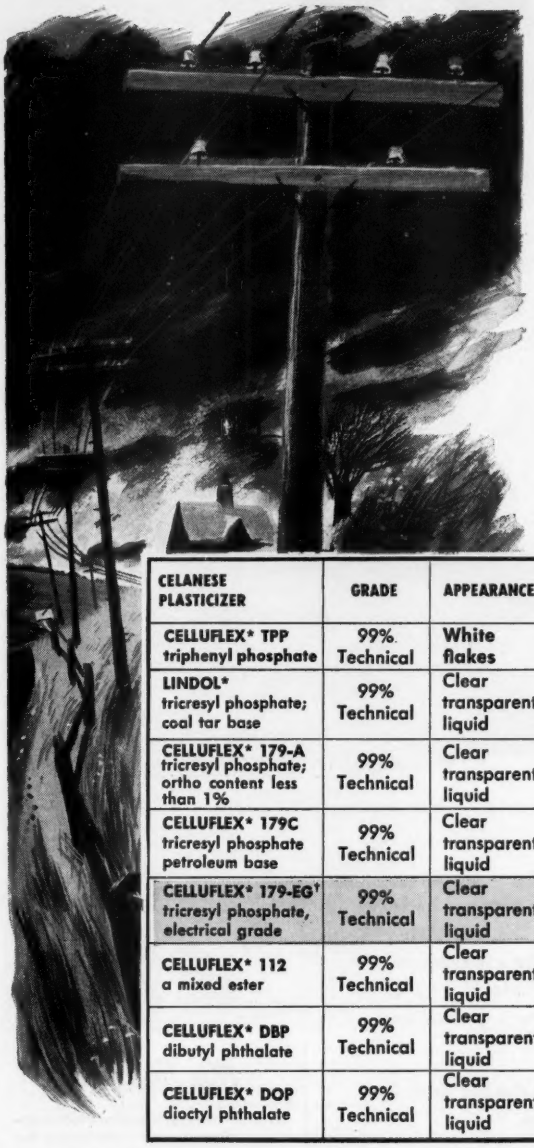
Our Field Engineering services and Guarantee of proper operation insure optimum performance of our gauges in your plant.

*This complements our widely used ½" MICROLIMIT CONTROL.

INDUSTRIAL GAUGES CORPORATION • WEST ENGLEWOOD, NEW JERSEY

Celanese CHEMICALS

PLASTICIZER



RECOMMENDED

CELLUFLEX* 179 EG

FOR

WIRE INSULATION

WHY

WEATHER RESISTANCE

DESCRIPTIVE DATA

CELANESE PLASTICIZER	GRADE	APPEARANCE	COLOR APHA Max.	SPECIFIC GRAVITY @20/20° C.	ACIDITY	ESTER VALUE % Min.	PERMANGANATE TIME, Min. (in Minutes)	WATER CONTENT % Max. by Wt.
CELLUFLEX* TPP triphenyl phosphate	99% Technical	White flakes	20 (3)	1.221 (1)	0.03 (2)	99	30	0.1
LINDOL* tricresyl phosphate; coal tar base	99% Technical	Clear transparent liquid	50	1.167 ± .005	0.1 (2)	99	30	0.1
CELLUFLEX* 179-A tricresyl phosphate; ortho content less than 1%	99% Technical	Clear transparent liquid	100	1.143 ± .006	0.1 (2)	99	30	0.1
CELLUFLEX* 179C tricresyl phosphate petroleum base	99% Technical	Clear transparent liquid	100	1.165 ± .005	0.1 (2)	99	30	0.1
CELLUFLEX* 179-EG† tricresyl phosphate, electrical grade	99% Technical	Clear transparent liquid	100	1.143 ± .008	0.1 (2)	99	30	0.1
CELLUFLEX* 112 a mixed ester	99% Technical	Clear transparent liquid	40	1.200 ± .005	0.1 (2)	99	30	0.1
CELLUFLEX* DBP dibutyl phthalate	99% Technical	Clear transparent liquid	25	1.045 ± .001	0.1 (2)	99	—	0.1
CELLUFLEX* DOP dioctyl phthalate	99% Technical	Clear transparent liquid	25	0.985 ± .004	0.1 (2)	99	—	0.1

(1) @60/60° C. (2) Mg. KOH/gram sample (3) Molten †Volume Resistivity: 16 megohm/cm x 10^7 at 23° C. min.

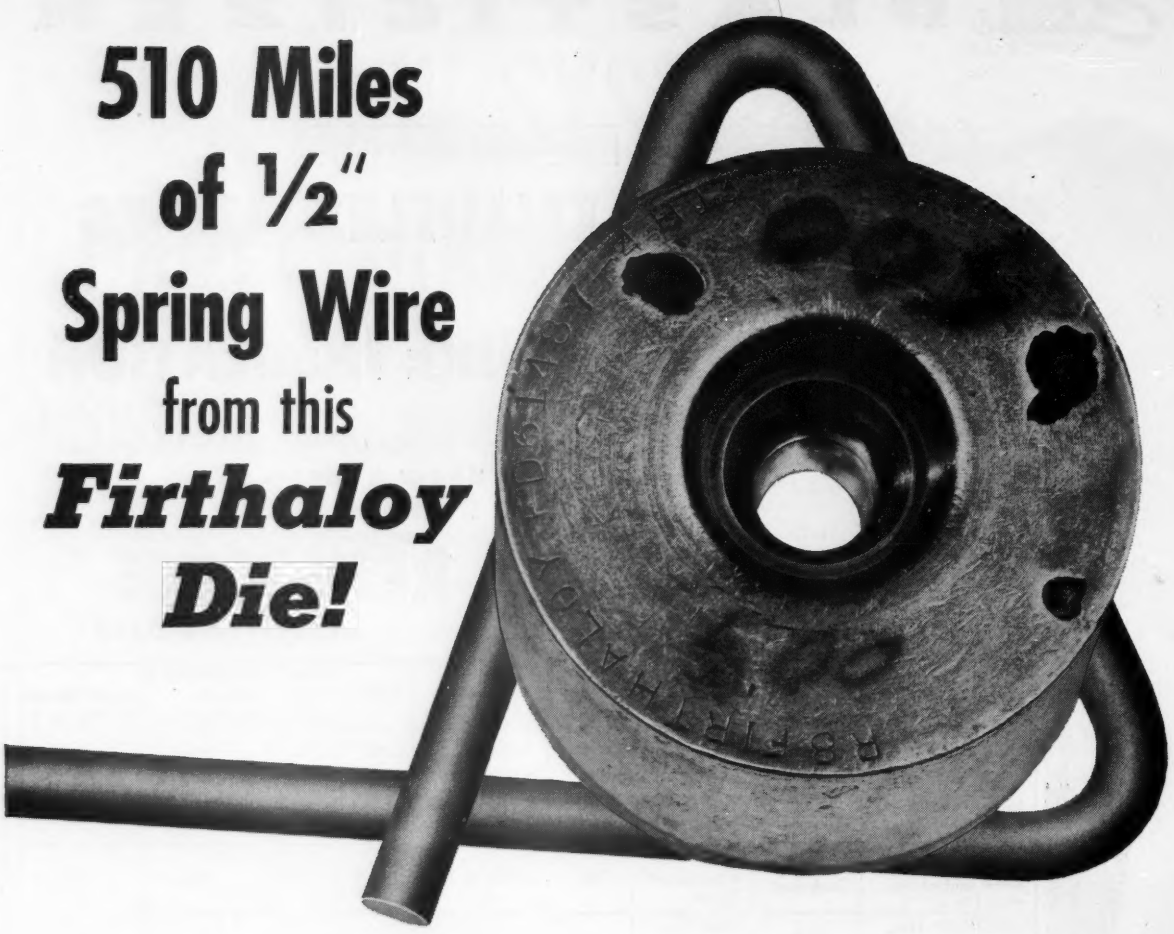
Where weather and high volume resistivity are major considerations, Celluflex 179 EG is the specified plasticizer. 179 EG (electrical grade tricresyl phosphate) imparts excellent resistance to weathering and maintains high insulation value in vinyl wire and cable coverings.

Celanese is an expanding source of plasticizers for many jobs. Bulk stocks at convenient distribution points are ready to meet tight schedules. Combination shipments — Celanese Plasticizers and Solvents or Intermediates — yield an extra dividend in price differential and freight savings. Be on our mailing list for new plasticizer developments. Please drop a card to Dept. 590-J Celanese Corporation of America, Chemical Division, 180 Madison Avenue, New York 16, N.Y.

*Reg. U. S. Pat. Off.

Celanese CHEMICALS

510 Miles of ½" Spring Wire from this *Firthaloy Die!*



The unretouched photo of the Firthaloy draw die above may not be very pretty—but what die would be after drawing 1,800,000 lbs. of ½" high carbon spring wire! The important fact is, that despite the appearance of the steel casing, the Firthaloy carbide nib (standard grade H-13) had worn *only 1/1000 of an inch when it was retired after 6 years of continuous service!*

The leading New England manufacturer who returned the die to us for our "museum" thinks his 1948 purchase was a good one.

You, too, can get comparable results when you specify *Firthaloy* for your own die shop or from your tool and die maker . . . in round, square, hex and all special shapes.

Write for information or literature today

Mr. Tooley says—

"Firth Sterling offers wire manufacturers and fabricators the advantages of a *single* source of supply for both tungsten carbide dies and high grade die steels. This *complete* line, from famous Firthaloy carbide through almost one hundred grades of high speed and tool steels saves you time and money."

R-312

Firth Sterling

—INC—

GENERAL OFFICES: 3113 FORBES ST., PITTSBURGH 30, PA.

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OFFICES AND WAREHOUSES*: BIRMINGHAM CHICAGO* CLEVELAND DAYTON DETROIT* HARTFORD* HOUSTON LOS ANGELES* NEW YORK PHILADELPHIA PITTSBURGH WASHINGTON WESTFIELD, N.J.

PRODUCTS OF FIRTH STERLING METALLURGY

High Speed Steels
Tool & Die Steels
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Sintered Tungsten Carbides
Firth Heavy Metal
Chromium Carbides
High Temperature Cermets
Zirconium

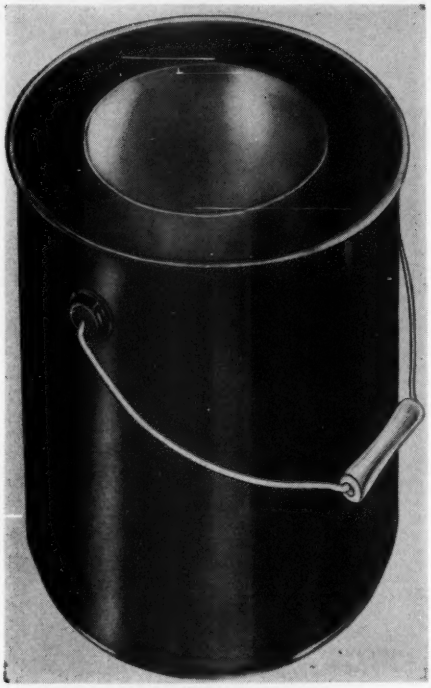
HUBBARD HAS IT!

HUBBARD HAS IT!

STEEL SHIPPING CONTAINERS

FOR

WIRE PAK



Hubbard Spool Company is proud to announce exclusive representation to the wire and cable industry for the Vulcan Containers, Inc. — manufacturers of all types of steel containers.

FEATURING:

- TOP AND BOTTOM SUPPORT FOR THE INNER CORE.
- SMOOTH SEAMS THROUGHOUT.
- PROMPT RAIL OR TRUCK DELIVERY.
- HUBBARD WIRE PAK PAILS HAVE SALVAGE VALUE.
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HUBBARD CONTAINERS HAVE MANY VALUES—

Write to us for details

HUBBARD SPOOL COMPANY

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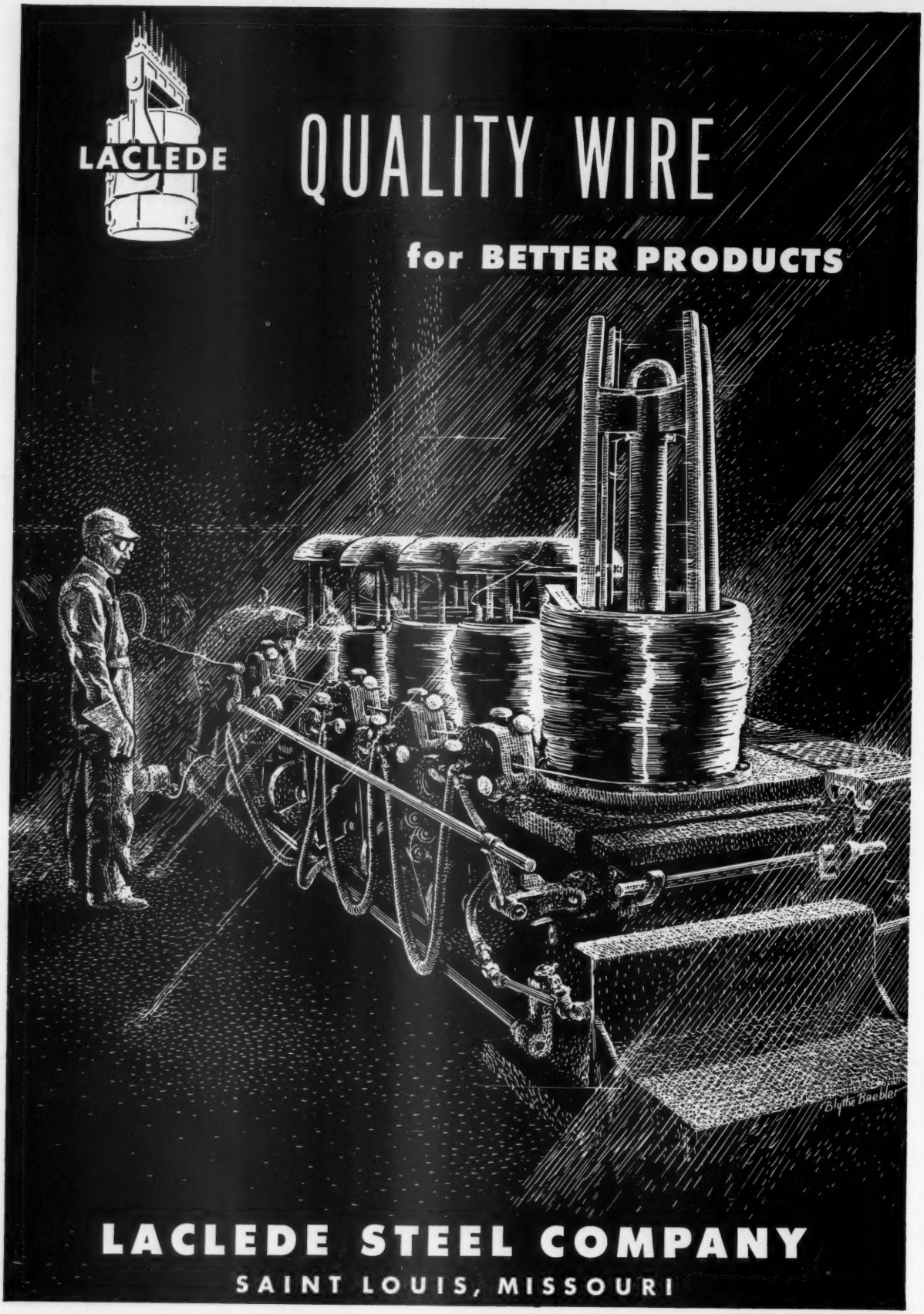
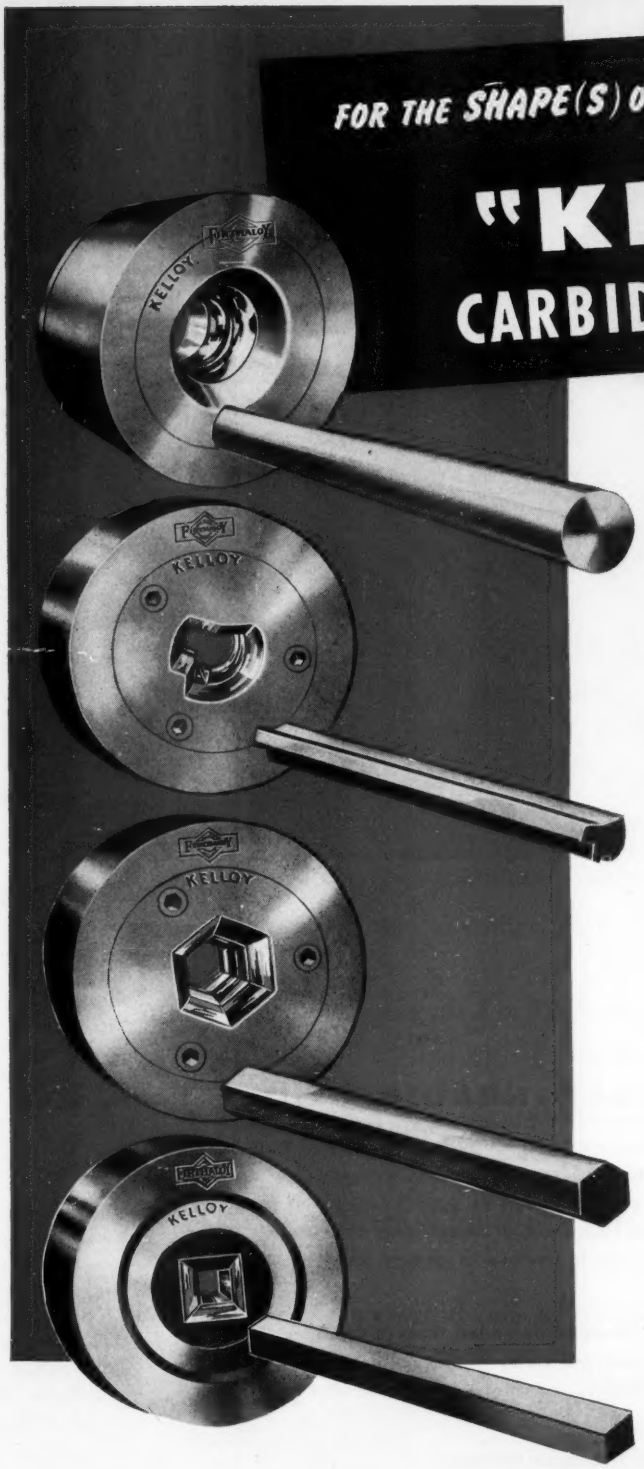
"THE BIGGEST NAME IN SPOOLS AND REELS"


LACLEDE
QUALITY WIRE
for BETTER PRODUCTS
Blythe Baebler
LACLEDE STEEL COMPANY
SAINT LOUIS, MISSOURI

FOR THE SHAPE(S) OF THINGS TO COME.. SEE...

"KELLOY" CARBIDE SHAPE DIES



A die shaped to wire manufacturers specifications, enabling him to satisfy the most exacting customer, demands a combination of experience and engineering not readily available in the average tool room.

That combination of experience and engineering is as much a part of Kelloy as the famous Firthaloy rough cores used in actual production.

The satisfaction of Kelloy performance can be yours too. Our engineering staff is available to assist you with your drawing problems. Simply write or telephone for price list or information.

Mandrels

The same exacting workmanship employed in Kelloy shape dies, assures the superior carbide mandrel for your every tubing requirement.

Authorized distributors and finishers of FIRTH STERLING die materials

KELLOY CORPORATION

30 WEST 35th. STREET • NEW YORK 1, N. Y.

You can sell the difference

SCOVILL EXTRUDED COLD-HEADING WIRE (Cartridge Brass, 70%)

. . . because of its higher copper content and production by the Hot Extrusion process from uniformly sound Continuous-Cast billets . . . virtually eliminates defects (when attributed to wire) such as split heads or shanks . . . "out of round" heads . . . inadequate filling out of heads and shoulders . . . and rough "orange peel" effect. These are differences in quality you can SELL in your cold-headed products.

Let us help you specify the proper closely controlled Scovill temper to produce more nearly perfect headed parts . . . whether you require "flow" characteristics for heading, or "flow" plus essential rigidity for secondary machining.

Scovill Manufacturing Company, Mill Products Division,
99 Mill Street, Waterbury 20, Connecticut. Phone Plaza 4-1171.

SCOVILL MILL PRODUCTS

BRASS • BRONZE • NICKEL SILVER • ALUMINUM

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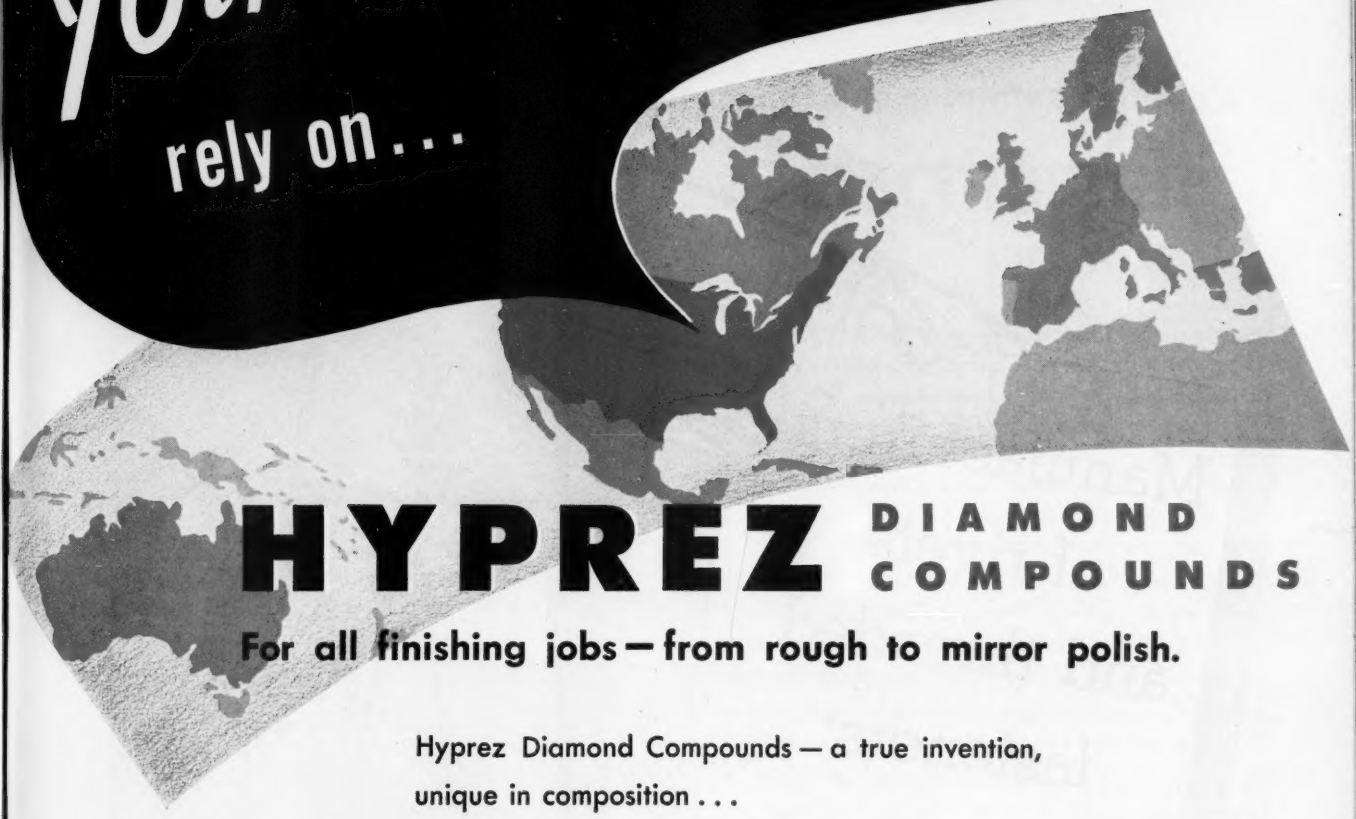
You and the world's industries rely on...



HYPREZ DIAMOND COMPOUNDS

For all finishing jobs — from rough to mirror polish.

Hyprez Diamond Compounds — a true invention, unique in composition . . .

- Are used in 19 foreign countries, in addition to the United States and Canada.
- Are patented in Switzerland, Sweden, Great Britain, and France.
- Are manufactured under exclusive license in Great Britain, Switzerland, and France.

This worldwide acceptance — the result of 15 years of research and rigid quality control — is guarantee that Hyprez will do your finishing job best.

HYPREZ, the original Diamond Compound, is available in types and grades for every finishing requirement; in 18- and 5-gram sealed cartridges for use with the Hyprez Applicator Gun.

HYPREZ DIVISION
ENGIS EQUIPMENT COMPANY
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LICENSEES
Engis Ltd., 25 Victoria Street, London SW-1, England
Durox S. R., 80 Rue St. Jean, Geneva, Switzerland
Laminor S.A., Annecy, France

think of... Kaiser Aluminum

To MEET the growing demands for aluminum rivets and threaded fasteners, Kaiser Aluminum produces for manufacturers a broad line of high quality rod and rivet wire.

Kaiser Aluminum wire is produced in sizes from 0.061″ to 0.374″ in diameter. Rod is produced in sizes from 0.615″ to 0.375″. Both are regularly available in six alloys: 1100, 2017, 2117, 2024, 6053, 5056. Others can be produced on request.

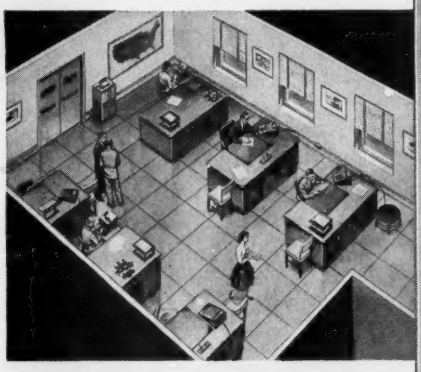
The many quality controls on Kaiser Aluminum rod and rivet wire assure rivets and fasteners that are strong, free from flaws and attractive in appearance—*that will meet or exceed minimum strength requirements.*

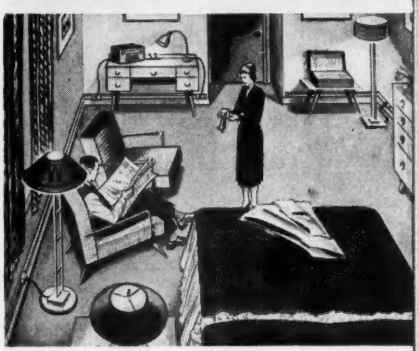
In addition to rivet wire and rod, Kaiser Aluminum also makes available a complete line of round drawn wire and hexagonal wire in a wide range of diameters, alloys and tempers. Redraw rod and redraw wire are available for further drawing into finished products.

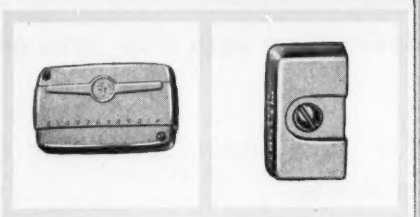
For immediate attention to your needs, contact the Kaiser Aluminum sales office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, Calif.

a MARVINOL®

"RIGID" Compound forms and insulates BullDog's new ELECTROSTRIP*







ELECTROSTRIP is a new flexible, plastic strip containing two concealed electric wires. Individually-fused receptacle plugs can be snapped into place, instantly, anywhere along its length. This eliminates long, dangerous extension cords and multiple plugs. Installed unobtrusively around the walls or baseboards of a room, office, display area, shop or store, ELECTROSTRIP brings power conveniently to lamps, home appliances, office machines, small tools, and other small electrical units up to a total of 20 amps.

Naugatuck supplies the MARVINOL "Rigid" (non-plasticized) vinyl compound which has proved ideal for this new product because:

- MARVINOL resins form a tough, strong strip which can be bent by hand to fit wall contours and turn corners.
- "Rigid" MARVINOL compounds are far superior to soft or plasticized vinyls in electrical insulating properties. ELECTROSTRIP is listed by Underwriters' Laboratories, Inc.
- The built-in color and smooth, attractive surface produced by MARVINOL resins provide a ready-made, permanent finish which can be painted over if desired.

MARVINOL resins provide compounds with extreme dimensional stability plus a controllable degree of flexibility. They are non-flammable and highly resistant to heat, oils, acids, alkalies and ozone... can be made either transparent or opaque. If you have in mind a new or improved product requiring any or all of these properties, be sure to consult with us about MARVINOL "Rigid" vinyls.

*Reg. & mfd. by BullDog Electric Products Co., Detroit

NAUGATUCK

Division of United States Rubber Company
Naugatuck, Connecticut

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BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario
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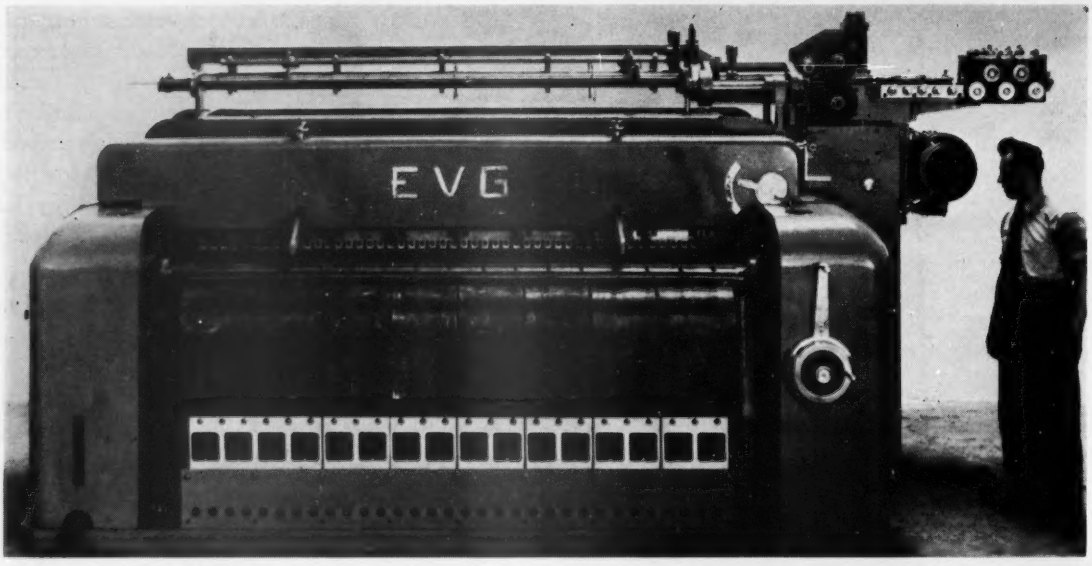
E V G

Europe's experienced builders of fully automatic, high-speed, horizontal type, precision

WIRE FABRIC WELDING MACHINES



Shown in Picture: The UNIVERSAL (Model G5); available in 96", 128" and 156" widths. Recommended for Road Fabric and Building Mesh.

EVG offers a series of fabric welding machines, individually designed for each major type and size of wire mesh, from the heaviest to the lightest.

Wire sizes from ½" diam. to 22 ga. Wire spacings from ½" x ½" upward, including all standard constructions. Speeds up to 90-100 cross wires per minute.

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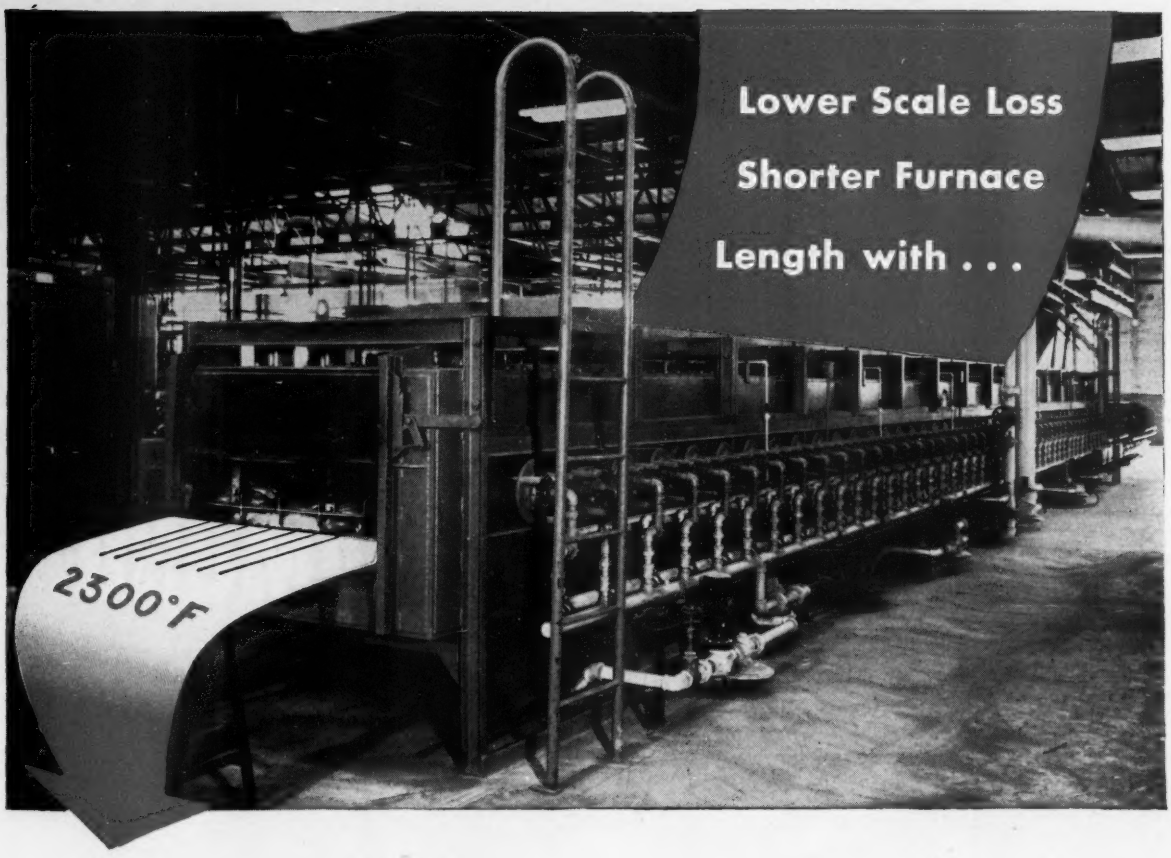

GASMACO wire patenting furnaces

GASMACO Wire Patenting Furnaces substantially reduce maintenance and operating costs and keep production at a steady pace. Elevated furnace temperatures heat faster; permit shorter furnace design and thus offer floor space bonuses.

Necessity of alloy muffle tubes eliminated. Indirect-fired GASMACO Patented Silicon Carbide Radiant Tubes virtually eliminate "down time," and supply high thermal head with atmosphere control over scale.

For a complete description of a GASMACO Wire Patenting Furnace at work, write for your copy of Bulletin A-105.

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Designers • Fabricators • Erectors
Gas Plant Equipment and Industrial Furnaces
THE GAS MACHINERY CO. (Canada) Ltd.
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meets rigid quality standards

at Allegheny Ludlum Steel Corporation, Pittsburgh

When wire is pulled through carbide dies, tremendous heat and pressure are generated. That is why the working surfaces of wire drawing dies must be polished to a near perfect finish. That is why Allegheny Ludlum uses Elgin Diamond.

Elgin Diamond assures the finest possible finish—and in less time—because all Elgin Diamond is precision graded and permanently suspended in a color-identified compound right in the Elgin laboratories. There are no oversize particles to scratch, no "fines" to decrease cutting efficiency.

Hundreds of die finishing applications prove Elgin Diamond reduces costs and produces a better finish every time . . . in less time! Now is the time to try Elgin Diamond and prove it to yourself!

Ask for a free demonstration!

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ELGIN NATIONAL WATCH COMPANY

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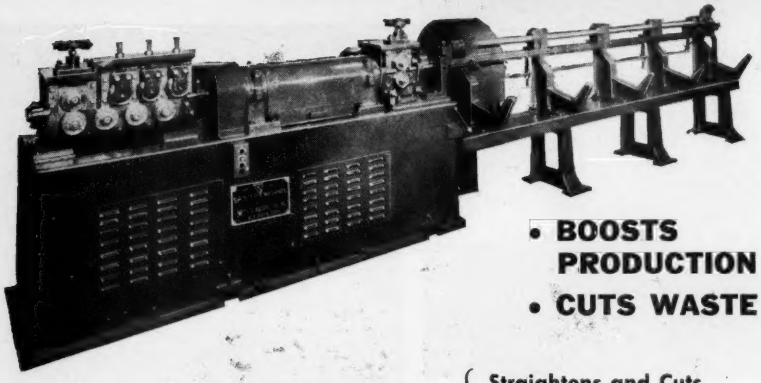
CONTROL IS THE GOOD WORD from SHUSTER



- BOOSTS PRODUCTION
- CUTS WASTE

Dual Control 3 AV { Straightens and Cuts ¼" to ½" diameter basic wire

Individual Control of Speed and Cut Off and Electrically Controlled Clutch and Target

With the Dual Control 3 AV you can run at the most efficient speed for the characteristics of the wire being used. And you get a clean cut at any length. Send for details.

A COMPLETE LINE

Constant Speed Machines **are available for straightening and cutting wire from .025" to ½"**

Constant or Variable Speed Units **with electrically controlled clutch and target are available from 1/16" to ½"**

Other variable speed machines may be furnished to straighten and cut wire up to 11/16"

ALSO

Slide Feed Straighteners **⅜" x 10"; 9/16" x 10"**
Feed Starters **maximum ⅝" diameter**

Tube and Bar Straighteners **7/32" to ⅝" bar; 1" tubing**

Reels **for coils up to 300 pounds**

Send for free, wall-size, split-gauge wire chart, from 41 gauge to 7/0.

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80 YEARS

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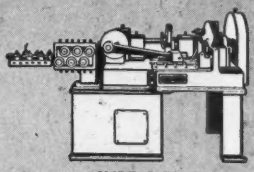
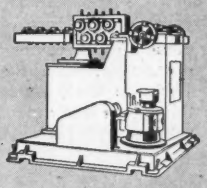
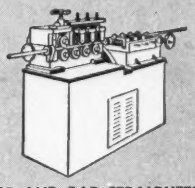
AMERICA'S OLDEST NAME IN WIRE STRAIGHTENING & CUTTING



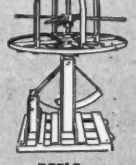
SLIDE FEED STRAIGHTENERS
3/8" x 10"; 9/16" x 10"



FEED STARTER AND STRAIGHTENER
Max. 5/8" dia.



TUBE AND BAR STRAIGHTENER
7/32" to 5/8" bar 1" tubing



REELS
400 lbs.

Gentlemen:

Please send us your recommendations. Our straightening and cut-off requirements are as follows:

.....

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Name .....

Firm .....

Street .....

City ..... Zone ..... State .....

PRIME MOVER. Here a wire belt is conveying pottery from a baking kiln to the decorating department. Wire belts, woven from CF&I-Wickwire Wire, are used to convey everything from heavy metal parts to fluffy foam rubber during processing operations.

CF&I-WICKWIRE MAKES WIRE FOR THOUSANDS OF USES

SHELF HELP for the housewife. These dish-washer shelves are made of selected low carbon rods of CF&I-Wickwire Refrigerator Shelf Wire. Specifications call for an extra-clean, smooth, bright surface for plating.

from making dishes for the manufacturer to washing them for the housewife... nothing can take the place of wire!

Wire can answer an almost incredible variety of needs because it can be varied to provide thousands of different combinations of mechanical and physical properties. From wire that can be easily twisted by hand to a rigid, self-supporting wire, it can be "tailor-made" to meet almost any set of requirements.

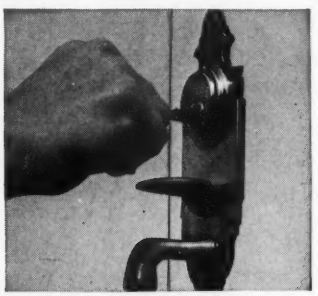
Whatever you assemble, manufacture, or process, let CF&I-Wickwire Wire help you do the job better, cheaper, and faster. You'll like doing business with CF&I-WICKWIRE and the careful attention given your own particular requirements.

CF&I-Wickwire Wire is made in plants conveniently located throughout the nation, from coast to coast. For detailed information, write our nearest district sales office.

WINDOW DRESSING. All kinds of draperies are hung on rods by means of strong, inexpensive drapery pins made from CF&I-Wickwire Drapery Pin Wire.

"RIBS" FOR HOSE. The rubber hose in grease guns is strengthened by basket-weave braided CF&I-Wickwire Hose Reinforcement Wire to help withstand high internal pressures. This wire is also used for rubber hoses in hydraulic brake lines and in hydraulic lines for aircraft.

FOR BACKYARD EXERCISE. These rake teeth are made of CF&I-Wickwire Rake Tine Steel Wire (flat scaleless tempered Spring Steel Wire).



ALL SECURE. The spring used in this lockset is made from extra-tough CF&I-Wickwire Lock Spring Steel Wire to insure long, dependable life.

3144

CF&I-WICKWIRE WIRE

THE COLORADO FUEL AND IRON CORPORATION—Albuquerque • Amarillo • Billings • Boise • Butte • Denver
El Paso • Ft. Worth • Houston • Lincoln (Neb.) • Oklahoma City • Phoenix • Pueblo • Salt Lake City • Wichita
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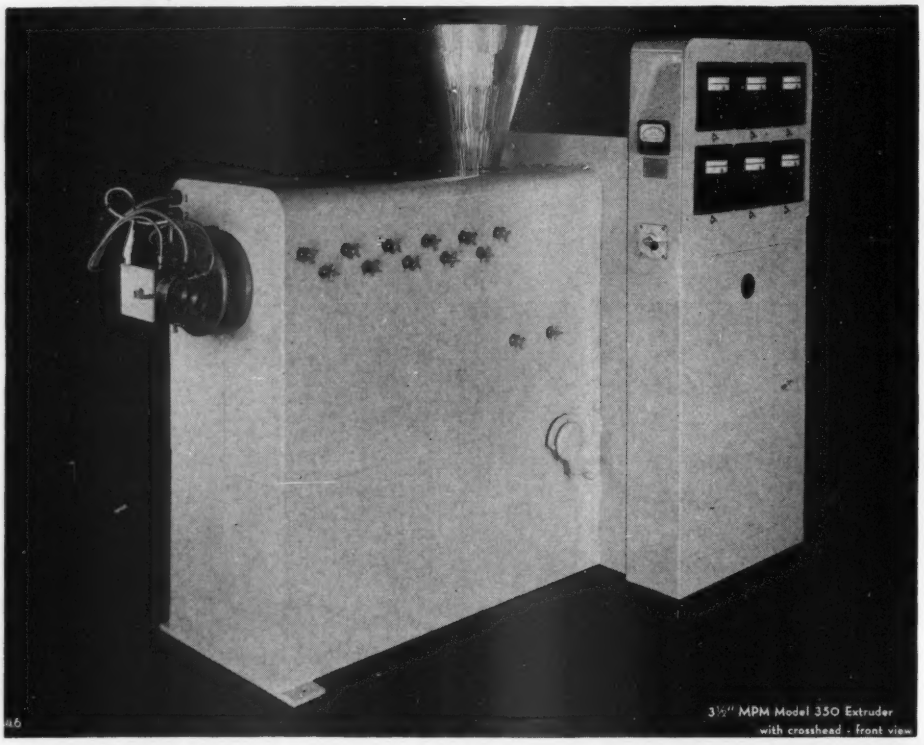
WICKWIRE SPENCER STEEL DIVISION—Atlanta • Boston • Buffalo • Chicago • Detroit • New Orleans • New York • Philadelphia

"Modern" INSULATING EQUIPMENT

is designed for those electric wire manufacturers who demand the best in extruders.



Shown at left: 3½" MPM Model No. 350 Extruder with crosshead, front view.

MPM Extruders are used by nearly all material suppliers, by laboratories for quality testing, and for production. One large electric wire manufacturer now has 17 MPM Extruders-reorders for them indicate the satisfaction they give.

MPM Extruders have the utmost flexibility and will handle a wide range of compounds and cross sections, as they are equipped with the best in temperature controls.

Literature upon request with questionnaire to determine the sizes, types and production requirements. MPM equipment is used in all principal foreign countries, indicating flexibility with many compounds.

Complete line of accessory equipment, such as dual take-ups, capstans, spark testers, measuring units etc.

MODERN PLASTIC MACHINERY CORP.

15 UNION STREET • LODI, NEW JERSEY, U.S.A.

Telephone GRegory 3-6218

HOW A NATIONAL-STANDARD WIRE DEVELOPMENT *keeps her hair prettier all day long*

Millions of pounds of steel are used each year to make bobby pins.

And it's a tricky steel to make, as we learned while developing it . . . tricky, that is, if our customers were to avoid fabricating troubles and hold manufacturing costs to a minimum.

We had to produce a special kind of round wire that could be flattened without cracking. It had to have an extremely uniform finish to facilitate coloring and to permit high speed processing without frequent costly adjustments of machinery. It had to be suitable for tempering to give the right springiness and tension.

Not only did our engineers succeed in meeting all of these challenges, but they also were able to save our customers money on manufacturing, packaging and handling.

We solve problems like these every day for our customers and give them better, more complete service than they get elsewhere. That's why National-Standard is industry's foremost supplier of special wire, wire cloth and strip steel. May we serve *you*, too?

NS NATIONAL-STANDARD Company NILES, MICHIGAN

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape
ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel
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Special Machinery for Metal Decorating
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Round and Shaped Steel Wire, Small Sizes

Fume Elimination . . . ONLY ONE OF MANY ADVANTAGES OFFERED BY CATALYTIC COMBUSTION

HERE'S MORE:

- Condensate formation and drip-back ELIMINATED.
- REDUCED fire hazard.
- Scrap-loss and shut-downs for oven cleaning sharply REDUCED.
- LIMIT PROTECTION on oven mal-function.
- NO ADDED OPERATING COSTS.
- Utilization of AVAILABLE HEAT ENERGY from fumes.

CATALYTIC COMBUSTION

a) is a low temperature oxidation process.

b) occurs when burnable fumes are passed thru the Suter-Ruff Catalyst.

c) destroys fumes completely, whether present as a slight trace, or up to the flammable range.

d) can be applied to the exhaust of existing equipment.

e) is adaptable to installations within existing furnaces, ovens, and other equipment where fumes are generated.

INSTALLATIONS OF CATALYTIC COMBUSTION SYSTEMS IN THE WIRE INDUSTRY number in the hundreds, including units for

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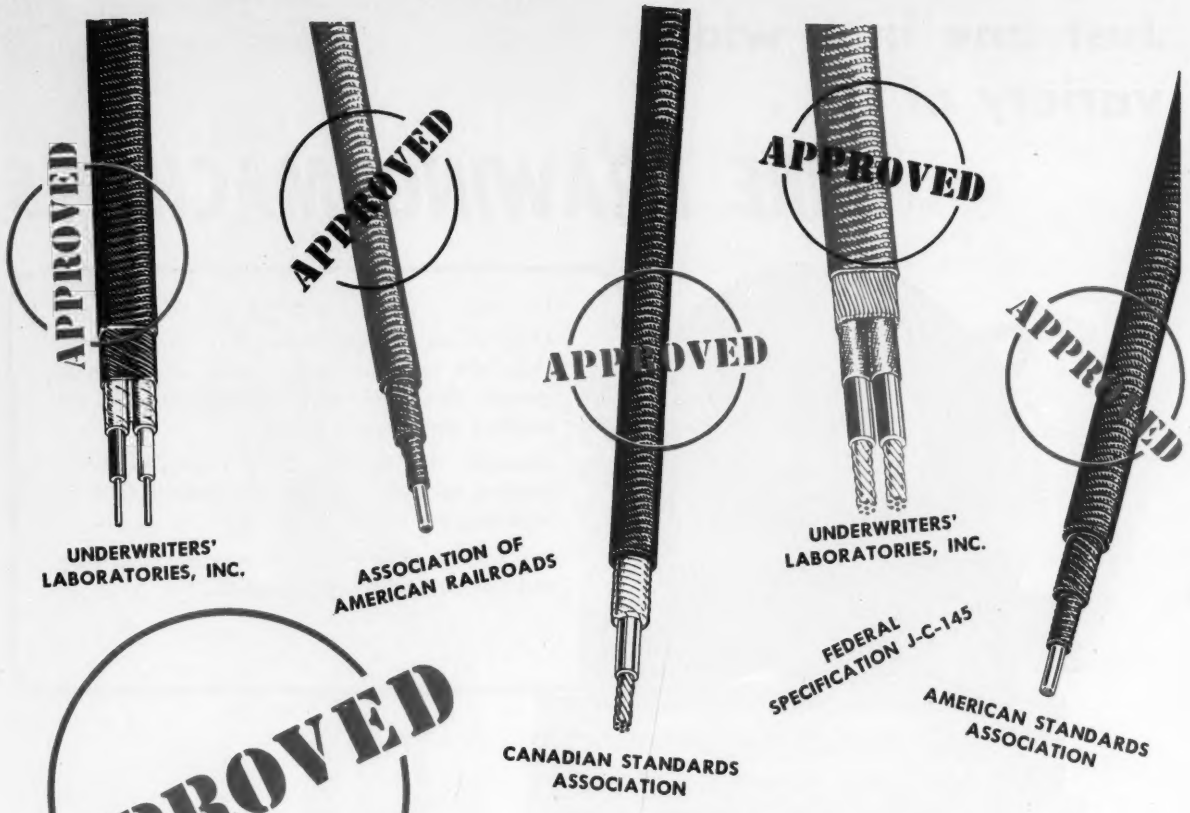
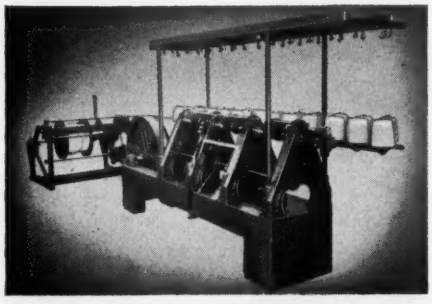


WIRE AND CABLE COVERING—AT HIGH SPEED

...WITH THE FIDELITY SINFRA KNITTER

WEATHERPROOF WIRE • BUILDING WIRE • NON-METALLIC SHEATHED CABLE • SERVICE ENTRANCE CABLE • OTHER GOVERNMENT & INDUSTRIAL WIRES



Sinfra Machines are available for covering wire sizes up to and including 500,000 C/M.

Your wire and cable can carry all the important stamps of approval—when you use Fidelity Sinfra Knitters in your covering operations. Wire and cable produced with these high speed wire covering machines meet the highest standards of recognized testing bodies . . . carry their authorized approval for industrial and military application.

Leading manufacturers agree, too, that the Sinfra Knit process has proven superior to conventional braiding methods of wire and cable covering. A Fidelity Sinfra Knitter covers up to 2500 feet of wire or cable per hour. Automatic electric stop motions and accurate product control permit the production of a better product at lower cost.

Many additional advantages of this amazing machine are described in Catalog W. Write for your copy today . . . or see the Fidelity Sinfra Knitter in the new show rooms at our plant.

Designers and Builders of Intricate, Automatic Precision Machines

SINCE 1911

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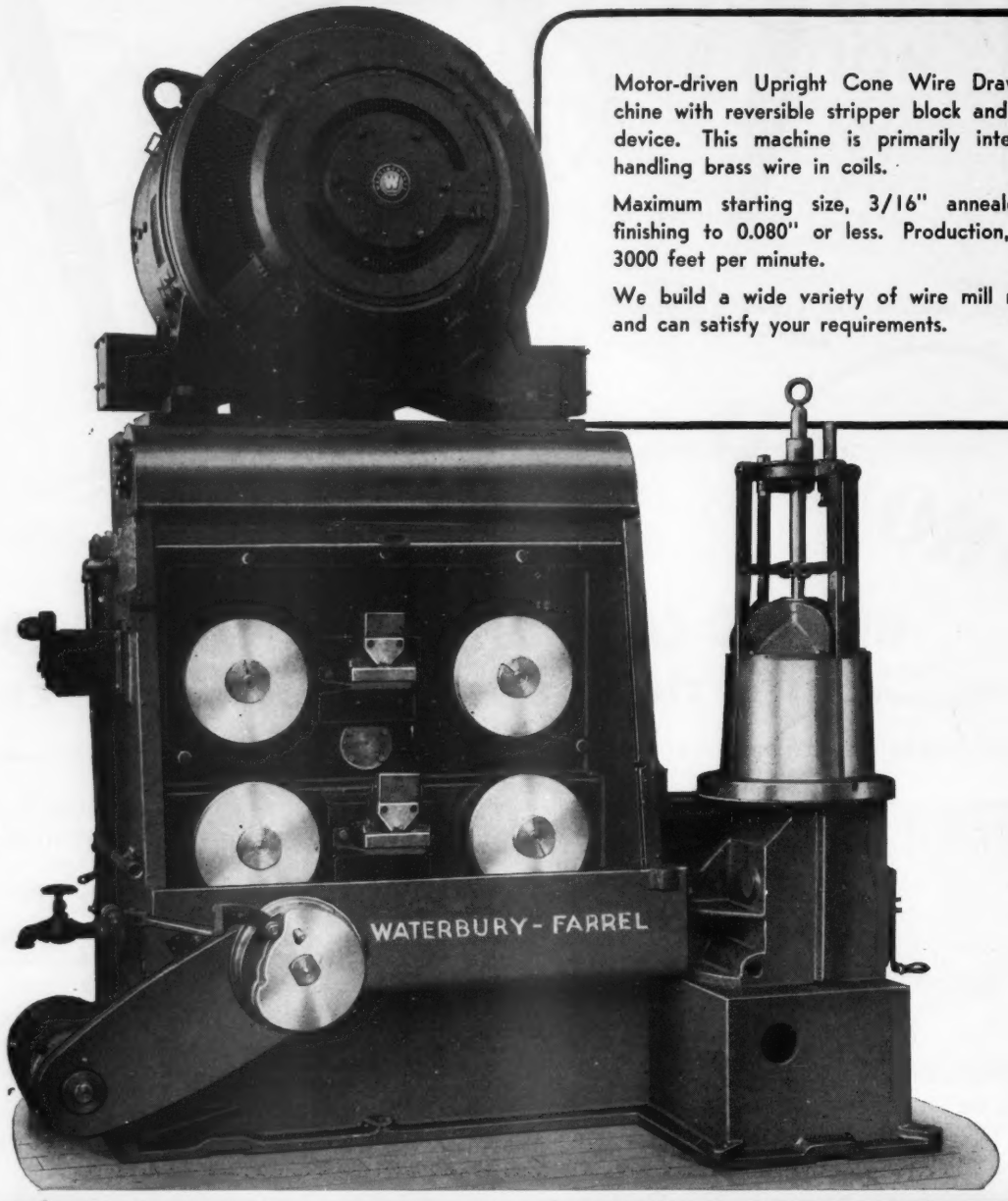
Just one in a wide variety of . . . .

WIRE DRAWING MACHINES



Motor-driven Upright Cone Wire Drawing Machine with reversible stripper block and string-up device. This machine is primarily intended for handling brass wire in coils.

Maximum starting size, 3/16" annealed brass, finishing to 0.080" or less. Production, 1000 to 3000 feet per minute.

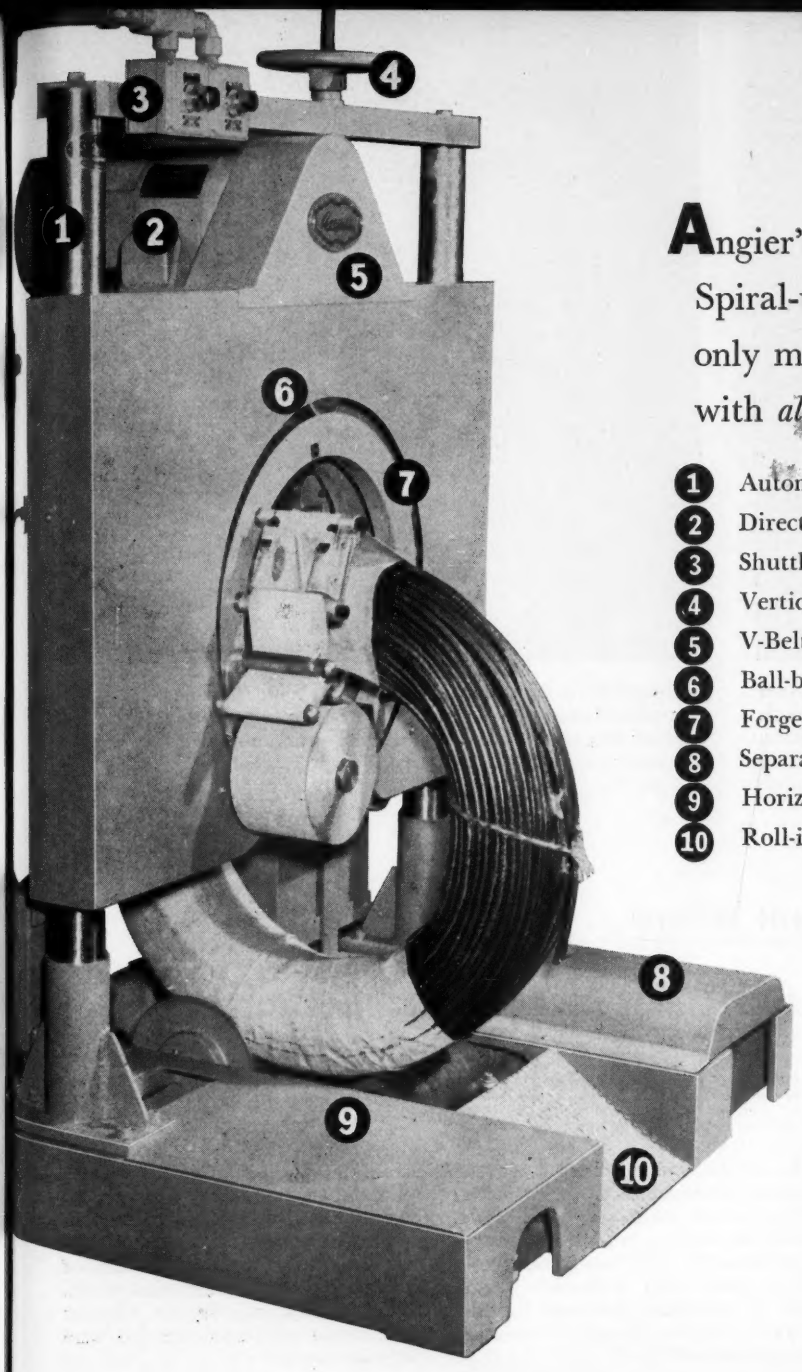
We build a wide variety of wire mill machinery and can satisfy your requirements.

WATERBURY FARREL FOUNDRY & MACHINE CO. • WATERBURY, CONN.

Offices: Chicago, Cleveland and Millburn, N. J.

WIRE MILL EQUIPMENT—Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers • Swagers • Bull Blocks • String-up Machines • Spoolers, etc. *COLD PROCFSS BOLT & NUT MACHINERY*—Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc. *POWER PRESSES*—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines • Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc. *MILL MACHINERY*—Rolling Mills; Strip, Rod, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc.

FOUNDED WATERBURY FARREL 1851



Angier's NEW #UW-10 Spiral-wrapper . . . the only machine on the market with *all* these features:

1. Automatic electric brake.
2. Directly connected high starting torque motor.
3. Shuttle jog control.
4. Vertical shuttle adjustment.
5. V-Belt shuttle drive (concealed).
6. Ball-bearing shuttle rolls.
7. Forged steel shuttle.
8. Separate motor for feed roll drive (concealed).
9. Horizontal feed roll adjustment.
10. Roll-in loading.

PAYING TOO MUCH to wrap coils ?

Angier

These are tested and *proven* features of Angier's new, economical #UW-10 Spiral-wrapper. Write for complete facts. See how you can cut your cost of wrapping steel strapping, cable or wire and other coils.

Send coupon now!

ANGIER CORPORATION, *Framingham 3, Mas*

Please send complete facts about Angier's ne #UW-10. Our product is_____

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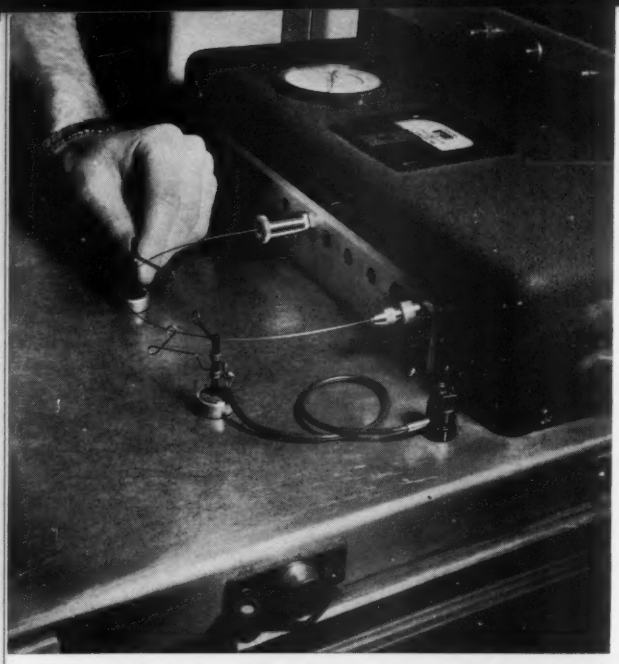
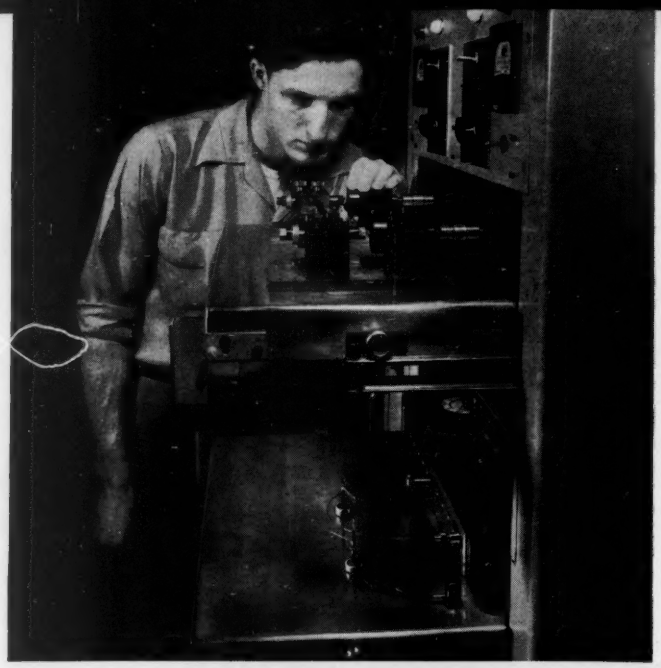




Design—Johnson music wire, to be used in a volume control spring for your television set, is looped through a 180-degree arc and rotated through millions of cycles on this rotating beam fatigue tester (left). The spring designed from this wire is then vibrated 50,000 times through its operating cycle (right). Test results enable Hunter engineers to select the most economical wire and spring design for the purpose.

Wire Must be Uniform Where . . .

Accurate Measurement of Quality Shaves Costs On Precision Springs

Cost saving through exacting accuracy in design and production of precision springs is a specialty at Hunter Spring Company.

Over the past 25 years, its plant at Lansdale, Pa., has become a thought-center in the industry. Today, this center is becoming increasingly important to spring development for radio and television, electrical and gas appliances, automotive equipment, controls and hundreds of other applications.

To build springs with the precision demanded at Hunter requires assurance of a continuing supply of special wire with consistent and uniform high quality.

For this reason, Hunter produces a large share of its springs from specialty fine wire supplied by Johnson Steel and Wire Company. Take music wire, for example. Starting with sizes as small as .003 inch in diameter (about the thickness of a human hair), so fine that one pound contains over seven miles of wire, Hunter's requirements range upward to diameters as large as .150 inch.

In production of more common springs, Hunter often starts with Johnson's oil tempered M.B. high carbon spring wire in diameters ranging from .030 to .080 inch. It supplements this range with sizes from .080. to .500 inch, produced by experts at Johnson's parent Pittsburgh Steel Company.

As a measure of the importance of uniformity in the wire, consider the unique methods and equipment Hunter uses to design springs.

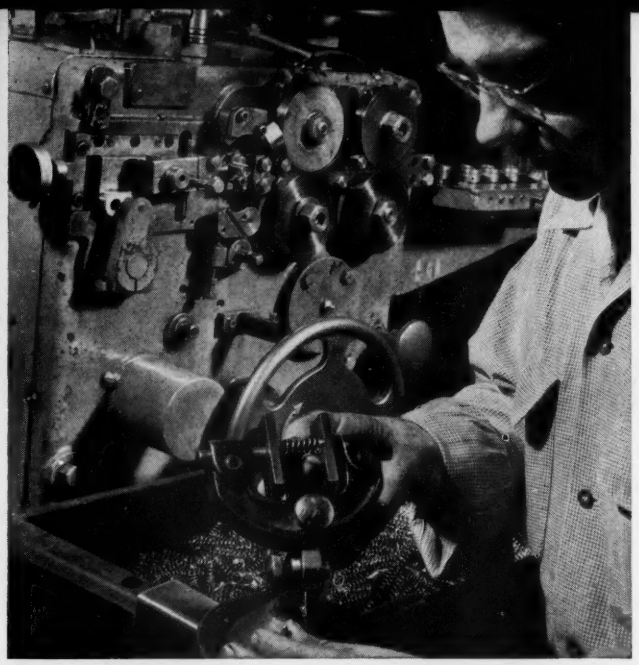
On rotating beam fatigue testers, developed by Hunter engineers, wire samples of predetermined length are looped through an arc and rotated at high speed. Studies of the number of cycles to failure indicate expected wire life in dynamic service. The life of springs made from this wire is compressed into a period of minutes by vibrating the spring through its entire operating cycle at high speed.

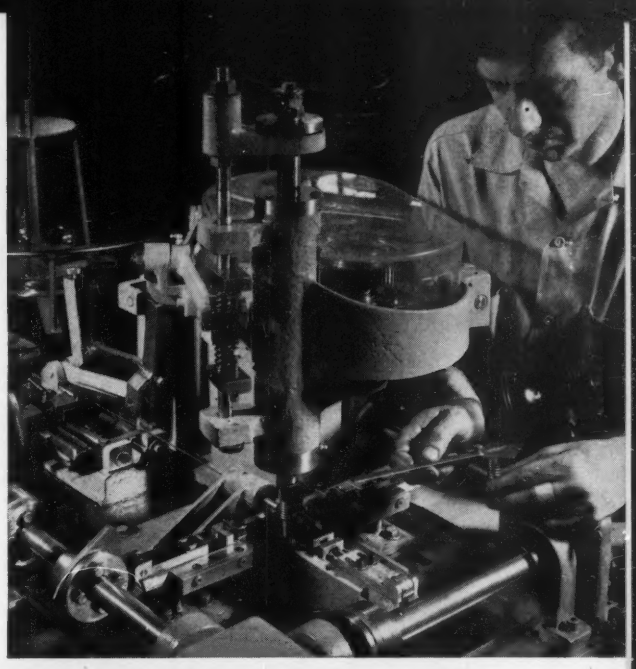
Test results of wire fatigue characteristics are correlated with those for the springs made from it. This enables Hunter to design springs for adequate service at minimum cost. Stress data for a complete range of wire and a wide variety of springs give Hunter research engineers an invaluable basic storehouse of information for economical design of springs. Yet, this information would be practically meaningless without dependable uniformity in the wire they are using.

Scientific quality control only begins with spring design, however. It is followed through with thorough inspection during production operations and a unique system for testing finished springs called "statistical quality control."

Hunter production facilities include modern high speed automatic coiling and torsion machines built to turn out precision compression, extension or torsion springs at machine-gun tempo. Special equipment is used to produce springs in a variety of intricate designs.

Secondary operations encompass grinding-of-ends on compression springs, forming-of-ends on tension or torsion springs, heat treating to relieve undesirable residual stresses





Production—Compression springs for high-quality locks made from .040-inch diameter Johnson music wire fly from this standard Torrington W-11 coiler at rates up to 5,000 an hour (left). The new Torrington No. 1 torsion machine equipped with multiple slides (right) is producing intricate refrigerator motor mounting torsion springs from .076-inch diameter music wire at rates up to 7,000 an hour. Each spring is precision built to exceed the life of the motor.

after cold working and plating or coating to resist corrosion—all accomplished on efficient up-to-date operating facilities.

To be scientifically sure that all of these factors, from the testing of wire through the design and production of springs, add up to the exact spring required by the customer, Hunter researchers now go to work again. Equipped with a complete line of testing apparatus for checking loads ranging from a few milligrams to 20,000 pounds, they test each shipment by (1) 100 per cent inspection, or (2) scientific sampling.

Delicate load testing equipment, for example, checks the amount of deflection in each spring. The piece-to-piece variation pattern in each shipment is sent to the customer in the form of a "statistical quality report." This report reduces inspection costs at the receiving end, provides a basis for decisions leading to changes in tolerance specifications, and assures the customer of receiving springs built for maximum performance at lowest cost.

Obviously, the success of this entire system is predicated on consistently uniform quality in wire from coil to coil and from shipment to shipment, even though the shipments may arrive at Hunter many months apart. To supply Hunter, Johnson Steel and Wire Company has geared production and testing techniques to meet these quality standards.

Do you use any of these specialty wires: Aircraft Cord, Armature Binding, Belt Hook, Bobby Pin, Brush, Gutterbroom, Card, Heddle, Shaderoller, Flexible Shaft, Hose Reinforcement, Hose, Mandolin, Piano, Rope, Safety Pin, Special Shaped, Staple, Metal Stitching, Signal Corps, Oil Tempered or MB Hard Drawn, Music Spring, or Tire Bead?

If so, why not take advantage of Johnson's long experience and modernized equipment to fill your requirements with quality wire you can depend on for uniformity? A call to our closest district office today will bring prompt attention!

Testing—Here delicate extension springs made from .009-inch diameter Johnson music wire to be used in record playing machines, are load tested. Under an initial tension of 8.44 grams, each spring is permitted a variation tolerance of only 1.23 grams (the weight of two paper clips). The variation pattern is sent to the customer in a statistical quality report.

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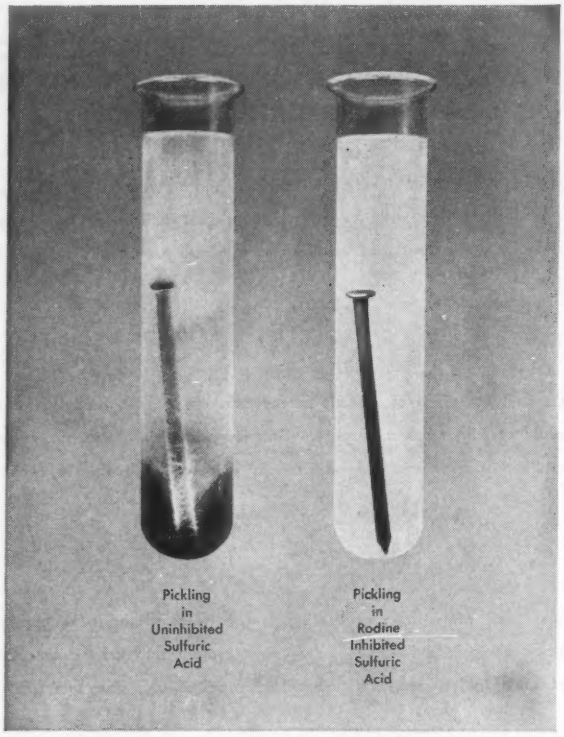
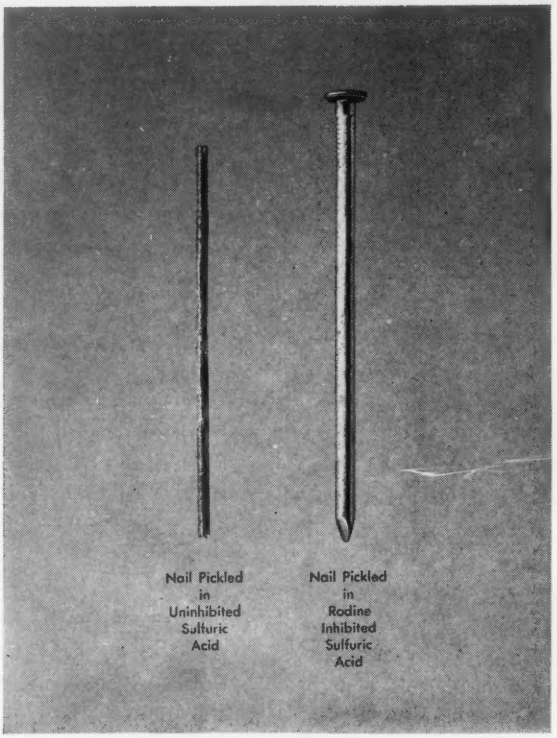
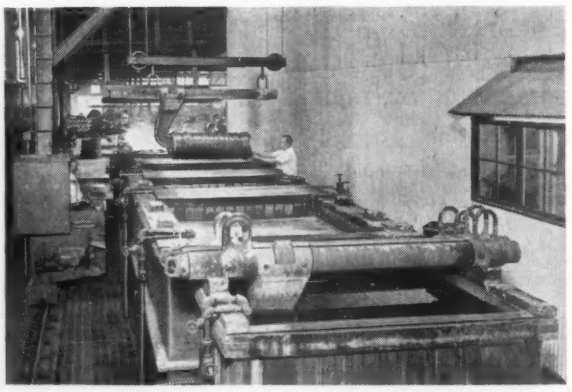


Formation of Hydrogen Test. Both test tubes contain a 10% by volume solution of sulfuric acid. In the left-hand tube, the acid is uninhibited. In the right-hand tube, a Rodine inhibitor has been added in an amount equal to 1% by volume of the concentrated acid. There is no bubbling in this tube—Rodine has retarded the formation of hydrogen that is the result of acid dissolving steel.



Loss of Weight Test. Both nails have been pickled in a 10% by volume solution of sulfuric acid for the same length of time. The nail pickled in the uninhibited sulfuric acid solution has lost its form, does not look like a nail any more. The nail pickled in the sulfuric acid solution with Rodine added has lost little weight, has retained its shape and luster.



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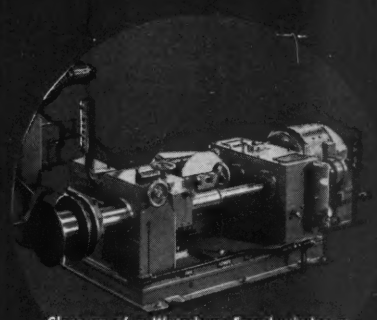
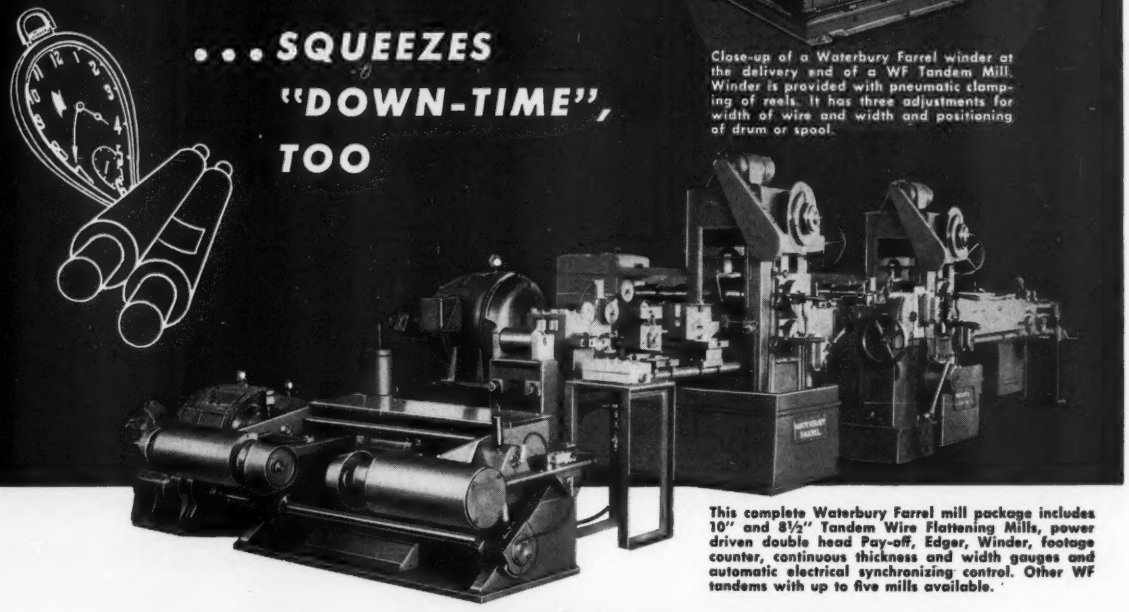


Close-up of a Waterbury Farrel winder at the delivery end of a WF Tandem Mill. Winder is provided with pneumatic clamping of reels. It has three adjustments for width of wire and width and positioning of drum or spool.



This complete Waterbury Farrel mill package includes 10" and 8½" Tandem Wire Flattening Mills, power driven double head Pay-off, Edger, Winder, footage counter, continuous thickness and width gauges and automatic electrical synchronizing control. Other WF tandems with up to five mills available.

Modern Waterbury Farrel Mill Design Insures High Production Plus Precision . . . Minimizes "Down-Time"

Here are some reasons why Waterbury Farrel Wire Flattening equipment can give you *more continuous,* high speed, precision production.

- Loading payoff and motor driven screwdowns for mills and edgers facilitate threading of wire with minimum effort and time.
- To protect precision operation, soluble oil is circulated internally and externally on the rolls and into coolant enclosures where wire is submerged. A refrigeration system maintains the coolant oil temperature at approximately 70° while a flotation unit keeps it clean and fresh. In addition, high speed mills also have a self-contained, automatically-filtered circulating mineral oil lubrication system for roll necks and drives.
- Transparent lucite covers at vital lubrication points such as gear cases and universal joints make it easy to check lubrication at a glance.
- Anti-friction bearings are used for all rotating members including the winder shaft. High precision anti-friction bearings are used on roll necks and edger arbors. This, combined with precision fitting of component parts enables WF mills to maintain tolerances well inside commercial allowance.
- Tungsten carbide ring rolls permit rolling the toughest alloys and increase roll life.
- Electric control keeps wire tension constant. Dancer rolls are used for fine wire.

Waterbury Farrel designs and builds a wide range of wire flattening mill equipment to suit specific requirements. Various sizes and combinations of single and multiple mill stands with auxiliary equipment are available for flattening ferrous and non-ferrous wire from the smallest diameters to 1" diameter and more. Speeds range up to and above 2500 FPM.

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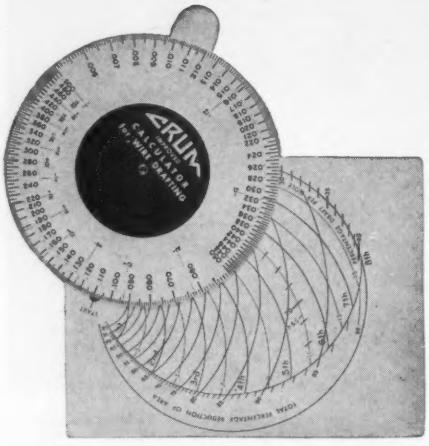
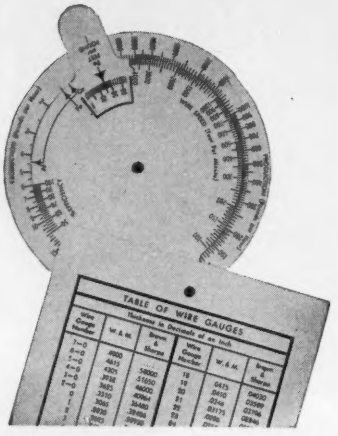


Front view of Crum Calculator.

THIS NEW DOUBLE-PURPOSE CALCULATOR WILL:

1. Provide quicker and more accurate information on die sizes and reduction areas;
2. Calculate wire production rates for various speeds and efficiencies.



Reverse view of Crum Calculator.

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- Gives readings in B & S gauges.
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- New rectangular shaped back for better protection of calculator.
- More legible % draft-per-hole scale.
- Vinyl plastic construction, resistant to wear, warping, dirt, perspiration, wire drawing soaps—can be cleaned.
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The improved Crum Calculator is worth its weight in gold in time saving —no laborious mathematical calculations necessary when you use it. Instruction sheet with examples accompany each Calculator. You should have one or more in your wire drawing department.

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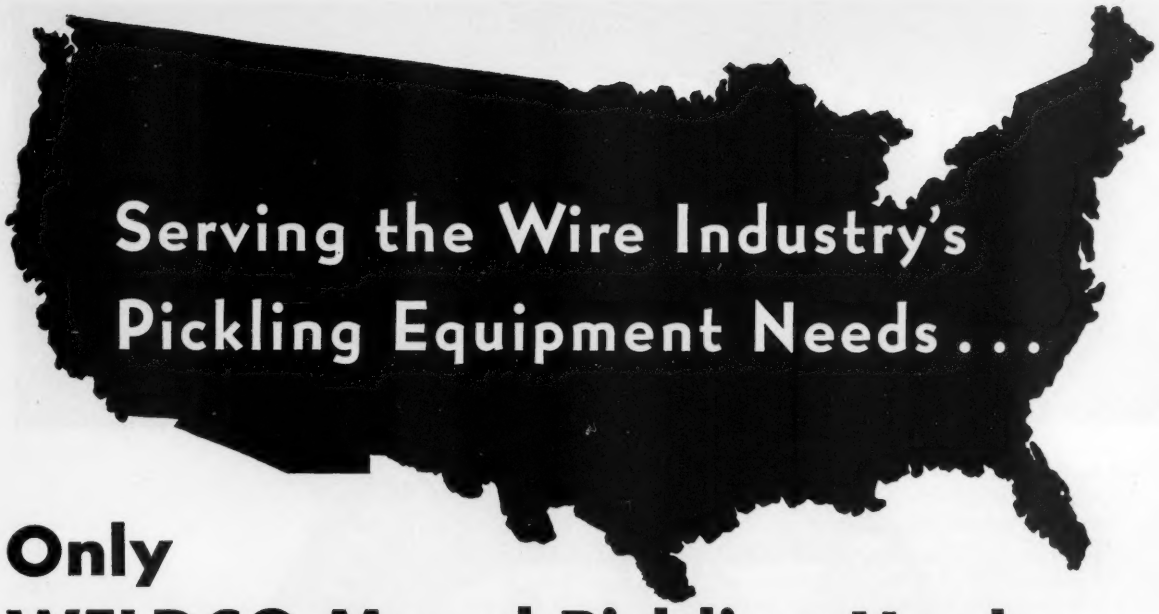

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The Wire Outlook

The pulse of business is showing a customary quickening with the coming of the cooler Fall weather, so much so that a more emphatic note of warning is being sounded.

The boom has developed so rapidly that more curbs are about to be applied. These will not be drastic enough to stop the rise, but will put a damper on it in the hope that it will not get out of hand.

Prices, too, are upping all along the line. As a concrete example, one model of a popular make of car that cost $2400 in 1951 is now, with equivalent equipment, some $800 higher. 1956 cars are expected to cost $150 to $200 more. The amazing thing is that people can and do buy them, in spite of the fact that depreciation is greater than ever.

Steel buyers who didn't think a year ago that there would be a shortage are kicking themselves for their shortsightedness. Orders are now being taken for deliveries in 1956. The shortages extend to almost all items except a few types of wire.

Big steel is not taking the challenge lying down. Huge expansion programs are in the making for the next few years. The capacity will have been increased by 5 million tons by the end of next year, 25 million tons by 1965 and 60 million tons by 1970, based on current plans. Present capacity is 125 million tons.

The copper shortage will be acute for many months. Copper and brass mills in New England will gradually get back to normal, but their removal from production does not help the consumers of non-ferrous products, who will be the ones to feel the pinch most, since inventories have been reduced almost to the vanishing point.

At the end of the second quarter the gross value of the nation's output of goods was $385 billion, with personal incomes at over $300 billion. By the end of the year, the gross national product value should be around $400 billion. This is all fine if the pace can be maintained and, from present indications, the momentum of business will carry over into next year, with no let-down in prospect.

Aluminum is enjoying a boom, some of it accounted for by the shortage of copper. Much more aluminum will be used by the electric wire industry and some of this business will stick due to the heights to which copper prices have climbed.

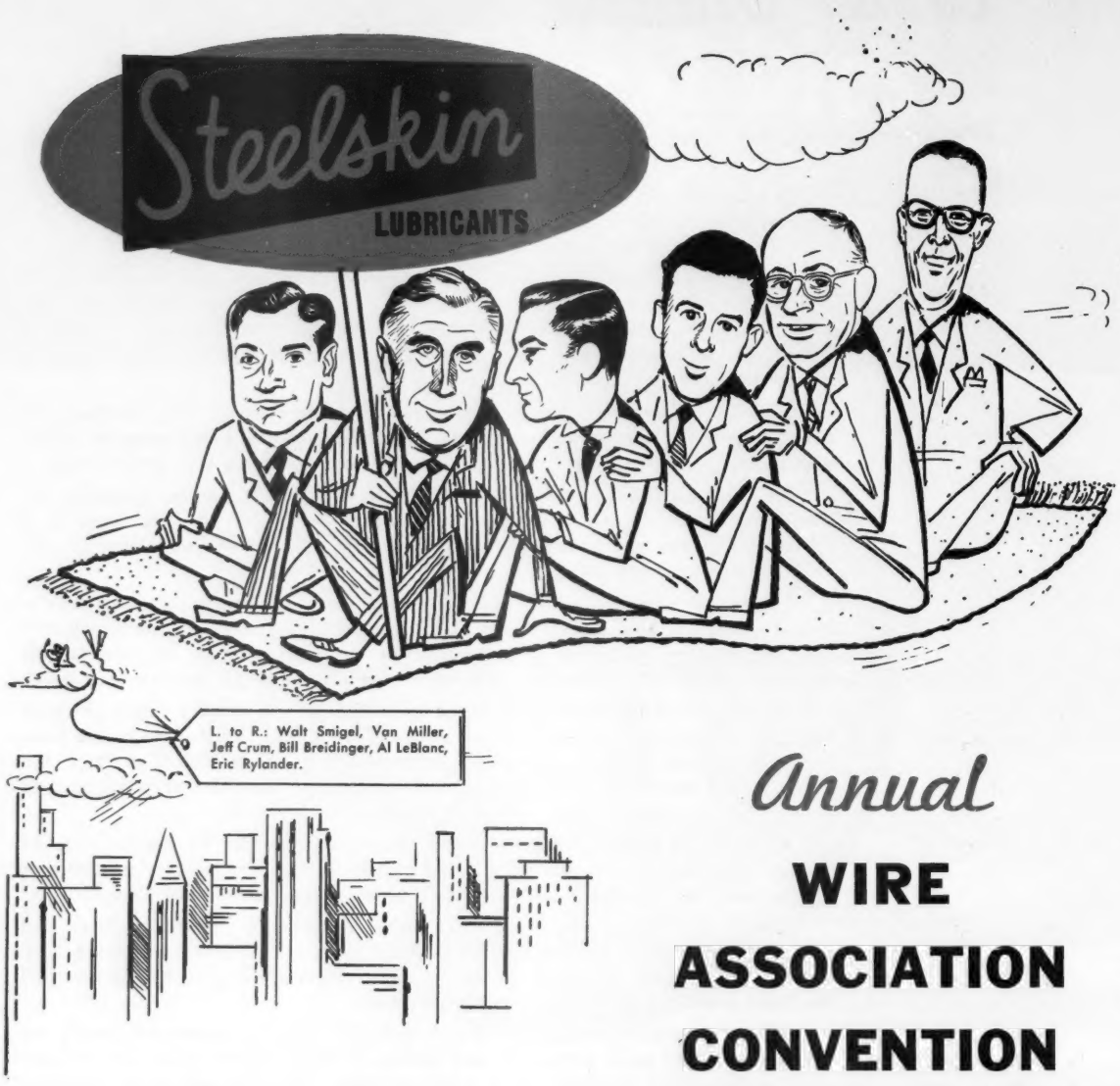
Strikes continue to plague industry needlessly. Labor is riding high, wide and handsome. It is estimated that about 650 strikes idled some 900,000 workers in July. The terrific economic losses occasioned by these strikes are bigger than those of all the flood and storm damages, great as they were.

Wire rods are in strong demand with deliveries slow, but consumers largely are getting what they need, except for non-ferrous products. Construction wire for concrete reinforcement continues to be a big mill item. Only fine wire is not booming. Fencing and netting is entering a seasonal lull. Rivet order backlogs are growing, accented by the recent flood reconstruction and new railroad car orders. The demand for automotive springs and spring wire will show little or no lag between model changes. In general, wire demand is good, inventories are low and supply is fair.

The wire industry is readying itself for its big Annual Convention in Chicago next month. Here top production men, engineers and others whose livelihood are concerned with wire problems will have an opportunity to listen and learn. The directors and officers of The Wire Association will take great pleasure in greeting old and new members again.

While we always have problems with us, both man-made and otherwise, out of them progress is born. Standards of production and of living will continue to improve. With this in view, the Convention can be expected to make its further contribution to the betterment of wire interests.

—from the Editor's Desk



Annual

WIRE ASSOCIATION CONVENTION

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WIRE
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A monthly publication devoted to the production of Wire, Rod and Strip.
DRAWING — ROLLING — EXTRUDING — FORMING — FABRICATING

Vol. 30 October, 1955 No. 10

Some Basic Principles of Continuous Electroplating of Wire

by A. B. Ashton
Research Manager
Frederick Smith and Company
Manchester, England

The art, or more properly the science of electrodeposition is one which has found a very wide field of application in the world of metals because it provides a means of allying the virtues of the basis metal with the superficial properties of the metal deposited upon it. The enormous range of the various combinations of properties which it makes available has resulted in a myriad of applications ranging from cigarette cases to searchlight reflectors.

★ ★ ★

Most of the development in this field hitherto has been on batch principles in which a discreet number of pieces has been treated in a batch which has passed successively from one treatment to another until it has emerged as finish plated products. It is true that much mechanisation and automation have been introduced into the process but it still has largely been applied to physically separate articles. In recent years, however, the wire industry has come to exploit the potentialities of the marriage between one metal and another and since wire makers and users have little use for short, physically separate lengths of wire it has become necessary to develop methods of quite literally continuously electrodepositing on to a moving wire. The wire for this purpose has to be regarded as endless.

A. B. Ashton

The author graduated from the Honours School of Metallurgy of Manchester University in England in 1933. He has been concerned with the metallurgy of copper and high conductivity copper alloys. His company is part of the London Electric Wire Co. and Smiths Ltd. He was made a Fellow of the Institution of Metallurgists in 1950.

Mr. Ashton prepared this paper for presentation before the Annual Convention of The Wire Association at its meeting in Chicago, Ill., November 14-17, 1955.

This feature introduces one or two features into electrodeposition which are novel to deposition on to wire. The mechanical design of the machines used for it is of course quite different from machines used for the mechanised plating of separate articles. This paper however is not concerned with this aspect of the matter; it is an aspect of considerable variety since machine design may vary from the enormous machines built for producing electrogalvanised steel to tiny apparatus designed to deposit platinum on to fine molybdenum. All machines, however, are based fundamentally on the primary laws of electrodeposition and it is the purpose of this paper to record the manner in which these laws are adapted and augmented by other considerations which are peculiar to deposition on to round wires.

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The importance of a study of this kind has two or three different aspects, all of which have practical values. In the first place it is often very important that the thickness of the coating be

held under strict control. In most instances familiar to the writer the emphasis lies towards guaranteeing that the thickness is not less than a stipulated minimum value. But this is not always so. In depositing silver, gold or platinum, for instance, it is obviously essential for economic reasons that only the minimum necessary thickness be applied and no more. Again in the case of copper clad nickel-iron wire of controlled expansion coefficient it is necessary that the deposit thickness be controlled to an exact figure so that the expansion coefficient of the composite wire may be correct. For all these conditions to be fulfilled the manufacturing procedure must be founded on a sound electrochemical basis, so that the wire may be correctly "tailored".

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Another aspect is that of machine design. Machines have to be built which will give the required outputs. These required outputs need to be translated into terms of electrochemical work before a machine can be designed which will execute the required amount of electrochemical work. Clearly then it is necessary to be able to work out this factor starting from the nature and quantity of the required output. Hence the arithmetical treatment which follows has practical value in machine design.

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Again it is often desirable to produce one particular wire combination on a machine which was originally designed for another. Or a designer may wish to build a machine which is intentionally versatile and designed to deposit a variety of metals in a variety of thicknesses at a variety of speeds on a variety of base metals. In either case the principles recorded in this paper must, in one way or another, be applied.

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The continuous plating of wires demands the same fundamental sequence of operations as any other plating operation. The wire must be cleaned most scrupulously so that a chemically clean surface is continuously presented to the electrodeposition cell. The methods of cleaning and washing must be completely reliable since it is impossible to inspect the metal between processes.

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When the wire is delivered to the electrodeposition cell the ordinary processes of electrodeposition commence. The wire is of course continuously moving but it is helpful in the analysis of the procedure to start from the conception of a stationary wire, and then introduce the consequences of movement. A further refinement is the introduction of the consequences of drawing down after plating. This of course thins down the electrodeposit and a thicker coating must be deposited than is wanted in the finished product. The analysis indicates how this factor can be accurately introduced into the plating operation.

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In the analysis which follows some assumptions are made. The wire diameter has a first order effect on current density since it governs surface area. It is assumed that the wire diameter does not change during the deposition; this is considered justifiable in most cases for the plating thickness in most cases is very small in relation to the diameter of the base metal. It is also assumed that the coating contributes nothing to the weight of output of a machine, for the same reason. One purely mathematical approximation is made in the analysis which will be indicated.

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On a stationary length of round wire the volume of metal deposited, from the ordinary laws of electrolysis,

$$= \frac{CTE}{\delta} = Lt\pi\ (D + t)$$

★ ★ ★

t is always small compared with L and D and it is therefore assumed that terms containing t^2 can be ignored, so that

$$\frac{CTE}{\delta} = LtD\pi$$

Hence

$$\frac{CE}{\delta} = \frac{L}{T}\, tD\pi$$

So that

$$t = \frac{CE}{SD\,\delta\pi} \qquad \text{.....(1)}$$

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So far then the thickness of metal being deposited is directly proportional to the current and inversely proportional to lineal speed and diameter of wire being plated.

★ ★ ★

In practice there are limits to the current which can be used since there is a limiting current density for each deposited metal above which the quality of the deposit deteriorates. It is quite essential that this current density be not exceeded. It is also desirable, in the interests of machine output, that this current density be maintained, since if it is not then metal is not being deposited at the maximum possible rate and

SYMBOLS.

SYMBOL.	DESCRIPTION.	UNITS.
C	Plating current	Amperes.
T	Time of plating	Minutes
E	Electrochemical equivalent of metal being deposited.	Lb. per ampere-minute
δ	Density of deposited metal.	Lb. per cubic inch.
δ_1	Density of core metal	" " " "
L	Length of wire being plated, or immersed length.	Inches.
R	Radius of wire being plated	Inch.
D	Diameter" " " "	"
t	Thickness of deposit	"
t_1	Thickness of deposit after drawing the plated wire.	"
d	Diameter of plated wire after drawing	"
S	Lineal speed of wire being plated	Inches per minute
C^d	Maximum current density permissible for the metal being deposited.	Amperes per square inch.
K	$\frac{C^d E}{\delta}$	

lineal speed must be sacrificed accordingly.

★ ★ ★

Under the conditions of the analysis so far the current density is $\frac{C}{\pi DL}$. Then, according to the principle laid down in the preceding paragraph,

$$C = C^a \pi DL. \quad \text{.....(2)}$$

★ ★ ★

Substituting this expression for C in equation (1)

$$t = \frac{C^a E}{\delta} \frac{L}{S} \quad \text{.....(3)}$$

★ ★ ★

So far then thickness of deposit has been related to immersed length, lineal speed and basic physical properties, and provision has been made for the use of the maximum current density.

★ ★ ★

If plated wire is drawn after plating, the deposited metal will be reduced in thickness in the same proportion as the reduction in diameter. Compensation for this reduction is easily made arithmetically in the formulae so that the latter relate the final (drawn) thickness of the deposited metal to the conditions of plating. An actual evaluation of the as-deposited thickness is therefore not necessary.

$$t = \frac{t_1 D}{d}$$

★ ★ ★

Substituting for t in equation (3)

$$t_1 = \frac{C^a E}{\delta} \frac{Ld}{SD} \quad \text{.....(4)}$$

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Since C^a is a fixed quantity (for any one metal under one set of plating conditions) and E and δ are basic physical properties of the deposited metal, the expression $\frac{C^a E}{\delta}$ can be simplified to K, of which some examples are given in the Table. The last equation then becomes

$$t_1 = K \frac{Ld}{SD}$$

Or

$$SD = K \frac{Ld}{t_1} \quad \text{.....(5)}$$

This equation permits calculations of weight output rates to be made. The weight output rate

$$= \frac{SD^2 \pi \delta_1}{4}$$

$$= SD \frac{D\pi\delta_1}{4}$$

$$= K \frac{Ld}{t_1} \frac{D\pi\delta_1}{4} \quad \text{.....(6)}$$

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These two equations, (5) and (6) are the basic relationships which are to be used in machine design and production planning, equation (2) being used to work out the plating current required when other factors have been decided.

★ ★ ★

The following are some practical points relating to the factors which appear in these two equations.

Lineal Speed (S)

This is generally the last factor to be calculated. Machine design is governed much more gravely by immersed length and plated diameter considerations than by lineal speed and these items are usually the first to be settled. Lineal speed can then be calculated.

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An excessively high speed however does carry with it some nuisances. Drag out losses tend to increase since the time for run-back of electrolyte down the wire is reduced. Also at high speeds wires tend to vibrate laterally and spatter the drag-out sideways over the machine structure; many electrolytes are corrosive to machine structures and in any case such spattering leads to dried deposits which militate against the cleanliness which is so essential in plating operations.

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Furthermore, time in the plating bath is not the only immersion time to be considered. High lineal speed carries with it the need to enlarge electrolytic and acid cleaning tanks in order to obtain the requisite immersion time to attain satisfactorily cleaned wire.

The maximum lineal speed the writer has satisfactorily coped with has been 4,800 feet per hour.

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If a machine is being designed to manufacture one single specific product only then it can be provided with a fixed speed drive giving a lineal speed which has been previously calculated, as mentioned above, after immersed length and plated diameter have been decided upon from weight output requirements. Only rarely, however, is it to be expected that a machine will run always on one product and sooner or later the question will arise as to what other products it will make. The variables which can be adjusted are as follows:—

(a) Current

This may be reduced from the figure calculated from equation (2); it cannot be increased, otherwise maximum permissible current density will be exceeded. The effect of this reduction will be to thin down the deposit. Hence the machine will produce a wire which will withstand drawing only to a bigger size than originally if the same thickness of coating on the finished wire is to be maintained.

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The weight output rate per hour will not be affected by the drop in current.

(b) Plated Diameter

Assuming that the machine has been designed to take a wire of a certain diameter, and no larger, then obviously the plated diameter cannot be increased and can only be reduced. If diameter is reduced then current must be also reduced in the same ratio since otherwise current density would be too high. Again this results in a thinning of the deposit, with the same consequence as before.

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Weight output is reduced in direct ratio to the reduction in plated diameter.

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These limitations stress the desirability of a variable speed drive in wire plating machines, even in those which are in the first instance being designed for one product only. If a variable speed drive is fitted then the machine is capable of a wide range of products (wide that is in terms of diameters and coating thicknesses) all of which can be made at high efficiencies. The writer has found it desirable to fit infinitely variable speed drives with a ratio of 30 to 1 between maximum and minimum speeds.

As an instance of the versatility which variable speed permits, the writer can quote the following data, which describe two different wires which he has produced on one and the same machine:

Material		Nickel plated copper.	Silver plated copper.
Finished size	inch	.0036	.048
Coating thickness at finished size.	inch	.0002	.00005
Plated diameter	inch	.025	.064
Lineal speed	inch/min.	23	516
Output rate	lb./min.	.00367	.522

Immersed Length (L)

The output is directly proportional to this, so a machine designer must attach high importance to it. In this connection he must consider two other matters. One is whether he will run the wire through the machine in a straight line or on a looping principle of some kind, the latter of course occupying less floor area than the former. Here he is influenced by the diameter and inherent stiffness of the wire he is plating; hard steel for instance is much more difficult to loop than soft copper, with the result for instance that electrogalvanising machines are generally of the straight-line type whilst machines for silver plated copper are based on looping.

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The second factor is the method of current feed. The longer the length the greater the current see equation (2) which the wire must carry. This current has to be fed into the wire at some point, or points, and moving contacts have to be designed to do this; a very long immersed length may result in difficulty in designing current feed contacts which will not mark the wire by arcing. Furthermore the wire must be capable of carrying the current without becoming overheated; chemically cleaned wires tarnish very readily when warm and if they tarnish before entering the plating bath then the plated coating is not adherent. The looping principle is advantageous in permitting the wire to come out of the electrolyte during each loop, which permits a contact point per loop and so lessens the current fed at each contact and the current carried by each strand.

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Contacts below the electrolyte level (such as are used in continuous anodising of aluminum) carry with them the nuisance of deposition on to themselves since they must be cathodic. They therefore change their shape and must be renewed at intervals. If the metal deposited upon them is in the precious metal category then it must be recovered.

Starting (Plated) and Finishing (Drawn) Diameters (D and d)

In designing a machine for a specified purpose the finishing diameter d is one of the factors specified, and is therefore not a controlled variable. The plated diameter D, however, can be chosen at will and, according to equation (6), directly governs the weight output rate. It is therefore profitable to make it large.

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A curious point here is that the weight output rate is proportional to D and not to D^2, which it would be in any other wire "pulling" operation. The reason for this is that if the wire diameter is increased the current must be increased in the same ratio see equation (2), but at the same time the speed must be reduced also in the same ratio see equation (4) as the thickness of coating after drawing (t_1) must remain constant. Thus, for instance, if the diameter of the wire be doubled, the lineal speed must be halved so that the overall effect is not a quadrupling but a doubling of output rate in weight per unit time.

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The limiting factors to the increase of D are primarily stiffness again, coupled with whether a straight line or a looped design is envisaged, and the problem of current feed contacts since equation (2) shows that current increases directly with plated diameter.

Current Density (C^d)

This quantity is embodied in the constant K so weight output is directly proportional to the current density employed. It is the most profitable of all the variables to study for an increase in it produces an increased output without demanding more immersed length, more floor space, or a greater plated diameter. Every effort should be made to devise an electrolyte with a high cathodic current density, coupled of course with high cathodic efficiency.

★ ★ ★

Elevated temperatures of the electrolyte and violent agitation of

(*Please turn to page* 1293)

TABLE

Values of K for common electrodeposited metals.

Metal	Max. current density (C^d) amps. per sq. in.	Electro-chemical equivalent (E) lb. per amp. minute.	Density (δ) lb. per in.^{3}	$\left(\frac{K}{C^d E}{\delta}\right)$
Copper (cupric)	.6944 (= 100 amps/ft^2)	.00004357	.3212	.00009419
Silver	.2083 (= 30 amps/ft^2)	.0001479	.3829	.00008046
Nickel	1.250 (= 180 amps/ft^2)	.00004022	.3215	.0001564

Reel Drive Selection

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PART I

The Selection Problem

Few applications require closer cooperation between the wire manufacturer, the machinery builder, and the drive designer than reel drives. The importance of this cooperation is steadily increasing as the industry demands higher production speeds, greater flexibility, and more dependable performance. These same factors have caused a shift from mechanical clutches and transmissions driven by the main machine motor to electric drives using a separate motor. This has placed additional demands on the skill and knowledge of the machinery builder and wire manufacturer. To obtain maximum production efficiency, they must know not only the process techniques and the machine design possibilities, but also the advantages and disadvantages of the many electric drives that are available.

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The six basic reeling applications are illustrated in Fig. 1. Although all of these reeling systems are important to the wire industry, most problems of drive selection concern Type 1 applications. Consequently, this article will be primarily concerned with this type, although many of the principles and problems discussed will also apply to other types of reeling applications.

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In Type 1 applications, the wire speed is established by the main process machine using a capstan, work rolls, or pinch rolls, and the function of the reel drive is to maintain the desired wire tension. There are many kinds of drives available for this purpose, but only two basic systems—**dancer roll (position) control** and **torque control,** and a clear understanding of the capabilities of each system is essential to obtain the best drive for a particular installation. With a dancer roll control system, the drive regulates the **position** of a roll supported by the wire and the tension is established by the mechanical design of the dancer roll stand. In a torque control system, the drive regulates the torque applied to the reel shaft. These two systems have many different characteristics. Some applications are most suitable for dancer control and others for torque control. To avoid confusing the characteristics of individual drives with those of the two systems, the relative merits of the systems should be considered before making a comparison of specific drives.

R. K. Larson

Mr. Larson graduated from the University of Illinois in 1943, receiving a B.S. Degree in Electrical Engineering, and then served with the United States Army in China for three years. He joined the General Electric Company in 1946, and after completing the Test Program entered the Large Motor and Generator Design Section. In 1949 he transferred to his present position in the Apparatus Sales Division where he is responsible for the application of electrical equipment for the Wire Industry. This paper was prepared for presentation at the Annual Convention of The Wire Association in Chicago, Ill., November 14-17, 1955. Due to its length, it is published in two parts. Part II will appear in November.

DEFINITION OF A DANCER CONTROL DRIVE

Some difficulty may be experienced in identifying the system used on many existing machines because of the lack of a universally accepted definition of "dancer control." Many reel drives in service in the wire industry today use intermittent control of the reel speed or torque by means of a movable roll or other device, and it is necessary to distinguish between these drives and a "dancer control" drive as defined in the preceding paragraph. These other drives include:

Movable Roll Speed Control

This system is illustrated in Fig. 2. In this case, the linear wire speed is established by the reel drive, not by the main machine drive. With this system, it must be possible for the wire to slip continuously on the main machine capstan. The wire tension between the reel and the capstan is then determined by adjusting the friction between the wire and the machine capstan. This system has been widely used on fine wire drawing machines. Here the reel is driven from the main machine motor through a mechanical, cone pulley, adjustable-speed transmission. As the reel fills with wire, the amount of wire in the control loop will decrease. After the loop has decreased a definite amount, the control arm will trip a limit switch or similar device. This causes a reduction in the speed setting of the adjustable-speed transmission, and the wire again begins to accumulate in the control loop.

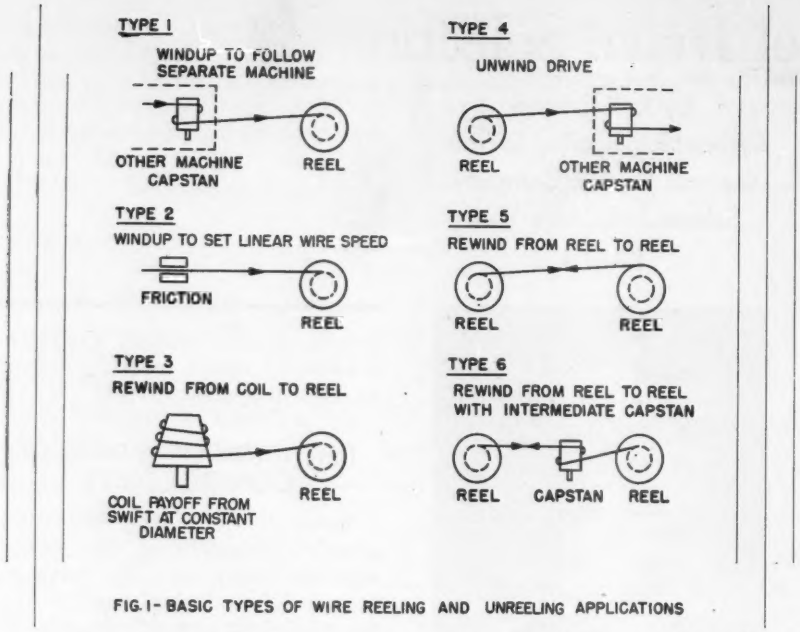
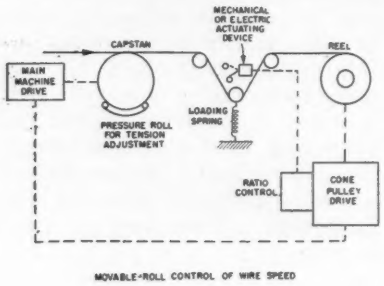
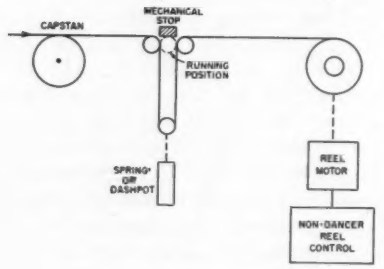


FIG. 1 - BASIC TYPES OF WIRE REELING AND UNREELING APPLICATIONS



MOVABLE-ROLL CONTROL OF WIRE SPEED

FIG. 2



MOVABLE-ROLL USED ONLY FOR ACCUMULATION

FIG. 3

Continued increase in the reel diameter will again "notch" the speed setting of the adjustable speed transmission. This action is repeated until the reel is full.

Movable Roll Torque Control

With this system, the speed-torque characteristic of the drive provided for the reel must be approximately the same as the tension load curve. Either a torque motor or an eddy-current clutch may be used. The movable roll will normally be held in approximately the center of its travel range by a spring or dash-pot arrangement. If the torque applied to the reel shaft is too high or too low, the movable roll will move to increase or decrease the drive torque as required. This system has been used on intermediate wire drawing machines, but has generally been discarded on newer installations.

Accumulation System

This arrangement is shown in Fig. 3. The movable roll does not exert any control on either the torque or speed of the reel motor. The movable roll may be loaded by a spring or by an air or oil cylinder designed to provide a dash-pot function. It will be free to move during acceleration or deceleration, but will be locked in position when the linear wire speed is constant. It can be used in conjunction with either a dancer or torque control system. With a dancer system, it would be used on a dual reel drive to prevent slack wire at the instant of transfer from a full reel to an empty reel. When used with a torque control system, it serves as a "buffer" during transient speed conditions to prevent the full effect of inertia forces from being transmitted to the wire.

Rider Roll

Rider roll drives are very similar to the movable roll speed control reel drives used on fine wire drawing machines. Here the position of an arm riding on the surface of the reel gradually reduces the reel speed. They are also speed control drives and suitable only for slip-type machines. The rider arm has always caused maintenance and operation problems, and this type of control is very seldom used.

Surface Belt Drive

Here the reel is driven by a belt held in contact with the wire on the barrel of the reel. This is also a speed control drive, requiring the wire to slip continuously on the main machine capstan, and the tension is controlled by adjusting the friction between the wire and the capstan.

Photo-electric Control

This is a speed control drive very similar to the movable roll speed control and the rider roll drives except that a photo-electric device is used to change the ratio of the mechanical, adjustable-speed transmission.

SLIPPING OF THE WIRE ON THE MAIN MACHINE CAPSTAN (DRY CAPSTAN OF A WET-TYPE MACHINE) DURING STARTING AND STOPPING

It will be observed that many wire reeling drives, particularly for wet-type wire drawing machines, control the speed of the reel, allowing the wire to slip on the final capstan of the main machine at all times, and the wire tension is established by friction. This constitutes a Type 2 reeling application. (See Fig. 1) While this method of operation is acceptable for fine wire drawing machines, few machinery builders or wire manufacturers wish to operate larger machines in this manner. However, elimination of slip during starting and stopping may be quite difficult and expensive. As a result many machines, particularly wet-type wire drawing machines use torque control reel drives to obtain Type 1 operation while running, but allow the wire to slip at the main machine (Type 2 operation) during

starting and stopping.

ESTABLISHING REQUIRED PERFORMANCE CHARACTERISTICS

As with all production machinery, the primary objective in the selection of a reel drive is to obtain the maximum ratio of production to installed cost. The first step toward this objective must be to establish the functional requirements of the process. The relative cost and performance of drives providing these functions can then be compared.

* * *

The basic functions of a take-up reel drive are these:

1. Accelerate without deforming the wire or allowing slack wire to develop.
2. Maintain acceptable tension over the build-up range of the reel.
3. Provide acceptable tension over the full linear speed range of the process.
4. Allow adjustment of tension for the full product size range.
5. Decelerate without deforming the wire or allowing slack wire to develop.

* * *

Achievement of these performance standards is a function not only of the take-up reel drive and the mechanical equipment but also of the main processing machine and its drives. The major factors influencing the performance are listed below.

Process Characteristics

1. Is the linear wire speed firmly established by the main machine?
2. What linear wire speed range will be required?
3. What size wire will be finished at each linear speed?
4. What wire tension is required for each wire size to maintain product dimensions and produce a satisfactory reel?
5. What is the maximum tension that can be tolerated during starting and stopping without breaking, stretching, or otherwise deforming the wire?
6. Can the wire or cable produced during acceleration and deceleration be held within tolerance? If not, how valuable is extremely fast acceleration and deceleration?
7. Will the main machine be stopped to change reels or will a "flying transfer" be used?

Main Drive Characteristics

1. Will constant horsepower or constant torque capacity be required over the normal running speed range?
2. If the desired linear speed range will be obtained by changing gear or pulley ratios, what ratios will be used?
3. What type of drive will be used?
   a. Adjustable-voltage, timed acceleration by regulator or motor-operated rheostat?
   b. Adjustable-voltage, timed acceleration by generator field time-delay relays?
   c. Wound-rotor motor with magnetic control?
   d. Wound-rotor motor with manual drum control?
   e. Constant-potential, direct-current motor with motor field control speed range?
   f. Squirrel cage motor?
4. If an adjustable voltage drive is used with timed acceleration, will the accelerating time be constant for all running speeds, or will it vary in proportion to the selected linear speed?
5. How is the drive stopped?
   a. Timed deceleration?
   b. Coasting?
   c. Dynamic braking?
   d. Mechanical braking?
6. How long will it take the drive to stop?
7. Is the deceleration rate constant or varying?
8. If the deceleration time is variable, what causes the variation?

Reel Characteristics

1. Empty and full diameter of each reel that will be used.
2. Empty weight of each reel.
3. Full weight or nominal capacity of each reel.
4. Approximate tension range that will be required at each linear speed.
5. Friction, windage, and traverse torque required over the normal running speed range.
6. Will stalled tension be required?

TABLE I

GUIDE FOR TENSION SELECTION*

Solid Wire

Wire Gauge (AWG)	Wire Diameter-(Inches)	Tension in Pounds	
		Copper or Aluminum	Steel
40	0.00314	0.1/0.2	0.3/0.6
35	0.00562	0.1/0.3	0.2/1.0
30	0.0100	0.3/0.8	0.5/2.0
25	0.0179	0.6/1.5	2/4
20	0.0319	1.5/4	3/8
18	0.0403	3/8	5/15
16	0.0508	6/12	8/16
14	0.0641	8/16	10/20
12	0.0808	15/30	20/40
10	0.102	20/50	30/60
8	0.129	30/70	40/80
6	0.162	40/80	50/100
4	0.204	50/100	55/120
2	0.258	60/150	60/150
0	0.325	80/200	80/200

Stranded Wire

0.25	35/100	35/100
0.375	40/120	40/120
0.500	50/150	50/150
0.750	50/200	50/200
1.00	60/300	60/300
2.00	150/600	150/600
3.00	200/800	200/800

These tension ranges will generally give satisfactory results although on some installations it may be desirable to select a tension range centered about the upper or lower limits given here depending on wire hardness, reel size, and disposition of the full reel.

*Based on wire with ultimate strength of:

Aluminum ..... 40,000 psi
Copper ..... 32,000/68,000 psi (Full soft/full hard)
Steel ..... 200,000 psi

INHERENT CHARACTERISTICS OF REEL DRIVES AND ADJUSTABLE-VOLTAGE DRIVES

Before discussing specific drive systems, it is advisable to identify the basic requirements of all Type 1 application (Fig. 1) center-driven reel drives and the inherent characteristics of adjustable-voltage, direct-current motor drives.

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Control of the linear wire speed, and consequently the reel surface speed, will be independent of the reel drive. The linear wire speed may be established by the main machine drive in the case of wire drawing, wire flattening, or wire stranding, while in other processes, such as wire insulating extruder lines, or wire tinning lines, the linear speed may be established by a separate capstan drive. While an adjustable-speed drive may be used on the main process machine to control the linear speed range, the linear speed will remain constant as the reel fills with wire. The speed of the reel motor must then decrease in proportion to the increase in reel diameter. Because of these conditions, two speed ranges are required for the reel motor. The first will be a function of the reel diameter, and the second will be a function of the linear wire speed.

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If constant tension is required and friction, windage, and traverse torque requirements are negligible, the torque applied to the reel shaft must increase in direct proportion to the increase in reel diameter. If it is desirable to reduce the tension as the reel fills, the torque may be held constant or increased at a slower rate than the increase in reel diameter. If more than one size of product is to be processed, it is also necessary to adjust the torque in proportion to the desired tension. Thus, in addition to the dual speed range, the reel drive must also provide two methods of torque control.

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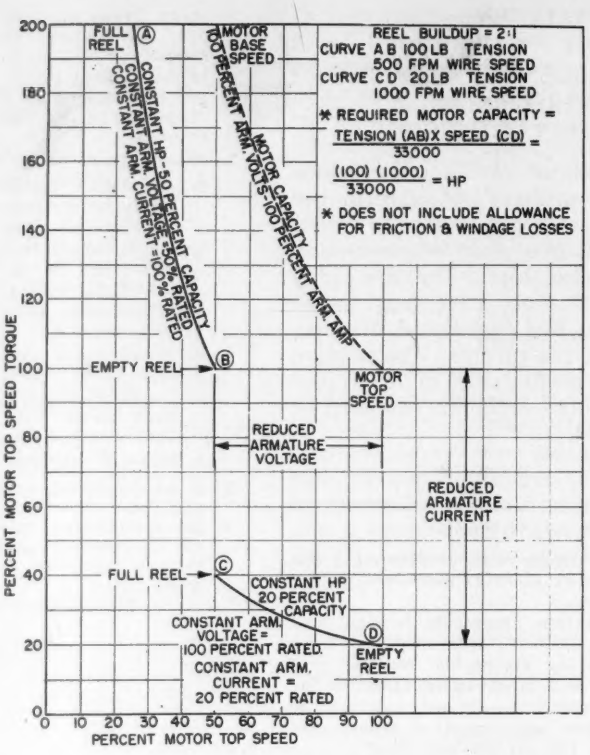
Since the reel drive must always be capable of applying tension to the wire, it is necessary for the reel drive to be able to provide a reel surface speed slightly higher than the linear wire speed with an empty reel. At the same time, to be sure that effective tension control can always be maintained, the reel drive must be able to provide a reel surface speed slightly lower than the linear wire speed with a full reel. If tension control is to be retained during starting and stopping, the reel drive must provide this control range from standstill to the maximum linear wire speed.


REEL BUILDUP = 2:1
CURVE A B 100 LB TENSION
500 FPM WIRE SPEED
CURVE C D 20 LB TENSION
1000 FPM WIRE SPEED
* REQUIRED MOTOR CAPACITY = TENSION (AB) X SPEED (CD) / 33000
(100) (1000) / 33000 = HP
* DOES NOT INCLUDE ALLOWANCE FOR FRICTION & WINDAGE LOSSES
FULL REEL
A
MOTOR BASE SPEED
CONSTANT HP-50 PERCENT CAPACITY
CONSTANT ARM. VOLTAGE = 50% RATED
CONSTANT ARM. CURRENT = 100% RATED
100 PERCENT ARM. VOLTS
MOTOR CAPACITY
100 PERCENT ARM. AMP
EMPTY REEL
B
MOTOR TOP SPEED
REDUCED ARMATURE VOLTAGE
REDUCED ARMATURE CURRENT
FULL REEL
C
CONSTANT HP 20 PERCENT CAPACITY
CONSTANT ARM. VOLTAGE = 100 PERCENT RATED.
CONSTANT ARM. CURRENT = 20 PERCENT RATED
D
EMPTY REEL
PERCENT MOTOR TOP SPEED TORQUE
0 20 40 60 80 100 120 140 160 180 200
0 10 20 30 40 50 60 70 80 90 100
PERCENT MOTOR TOP SPEED

SELECTION OF MOTOR FOR COMBINED TENSION AND LINEAR SPEED RANGE

FIG. 4

By using an adjustable-voltage, direct-current motor drive, it is possible to obtain drive characteristics that exactly match the basic requirements of the constant-tension reeling load. (Refer to Fig. 4) Two essentially independent motor speed ranges may be obtained using motor field voltage control and motor armature voltage control. Increasing the motor field voltage will decrease the motor speed. At the same time, the torque **capacity** of the motor (**devoloped** torque will depend on the load) will increase in direct proportion to the decrease in motor speed. This is exactly the relationship between speed and torque that is theoretically required to maintain constant tension from an empty to a full reel. If the motor field voltage is held constant, and the armature voltage is reduced, the motor speed will decrease in approximately direct proportion. When using armature voltage control, the torque **capacity** of the motor will remain constant as the speed is reduced except for the effect of reduced ventilation. With suitable control, both speed ranges may be obtained simultaneously. See Table 2.

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While the motor field control speed range is not completely independent of the armature voltage, there is little interaction unless the armature voltage is well below the rated value. As the armature voltage is reduced, the effectiveness of motor field control will be decreased, and it will have no influence on motor speed when the armature voltage is zero. To offset this condition, control circuits are usually designed to provide a change of from 10 to 30 per cent in the armature voltage as the field strength is varied from the maximum to the minimum value. With

this arrangement, the motor field control circuit will be effective down to zero speed.

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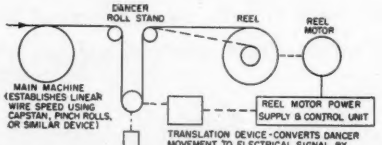
Motor field control will normally be used to compensate for change in reel diameter, and armature voltage will be varied in proportion to the linear wire speed. However, on some drives, particularly when using dancer roll control, the entire motor speed range may be obtained by armature voltage control. In this case, since the motor must have sufficient torque **capacity** for the desired tension with a full reel, and will have the same **capacity** at the higher speed required for an empty reel, the horsepower rating of the drive will be higher than when motor field control is used. A similar condition exists, even when motor field control is used for the reel build-up speed range, if the tension required at low linear speed is greater than at high linear speed. Since armature voltage control will be used for the linear speed range, the drive will have sufficient torque capacity to provide the same tension at the maximum linear wire speed as at the lowest wire speed.

DANCER CONTROL DRIVES

Two basic dancer roll drive systems are in common use in the wire industry today. The mechanical arrangement will be the same for both systems. (Figure 5)


DANCER ROLL STAND
REEL
REEL MOTOR
MAIN MACHINE (ESTABLISHES LINEAR WIRE SPEED USING CAPSTAN, PINCH ROLLS, OR SIMILAR DEVICE)
REEL MOTOR POWER SUPPLY & CONTROL UNIT
TRANSLATION DEVICE - CONVERTS DANCER MOVEMENT TO ELECTRICAL SIGNAL BY RHEOSTAT OR REACTOR
LOADING DEVICE - ESTABLISHES TENSION BY AIR, HYDRAULIC, WEIGHT, OR OTHER MEANS

DANCER ROLL CONTROLLED REEL DRIVE

FIG 5

Continuous Position Control System

In this system, any movement of the dancer roll produces a proportional change in the speed of the reel shaft. The change in reel shaft speed will always be in such a direction as to oppose further movement of the dancer roll, and operation will be equally effective regardless of the direction of the dancer roll movement. To obtain this performance, the drive torque must be fully reversible at any speed. Suitable drives for this type of system include direct-current motors, hydraulic motors, and mechanical, cone pulley, adjustable-speed transmissions.

Discontinuous Position Control System

This system operates in exactly the same manner as the first system, except that positive control of the reel shaft speed is only obtained for one direction of dancer roll movement. This system is the result of using a drive with non-reversible torque characteristics. Typical drives are an adjustable-voltage, direct-current motor supplied by an electronic rectifier, eddy-current couplings, friction clutches, or wound-rotor motors. This system has two limitations that are not present with a continuous position control system. It is more difficult to calculate the wire storage required for successful operation so it is frequently necessary to make an estimate based on past experience. Since it is seldom that two reel drives have exactly the same operating conditions, this leaves substantial room for error. The storage required for a continuous position control system, on the other hand, can be calculated quite simply. As a rule the con-

TABLE 2

INERTIA OF COMMON REELS

Nominal Capacity (Lbs.)	Barrel Dia. (In.)	Flange Dia. (In.)	Empty Weight (Lbs.)	Full Weight (Lbs.)	Empty WK^2 (Lb.Ft.^{2})	Full WK^2* (Lb.Ft.^{2})
50	6	16	16	65	2	13
120	7	12	28	150	3.4	24
250	9	16	55	300	11	85
500	11	22	115	615	40	300
1000	16	30	230	1500	260	1400
2000	18	36	420	2400	380	2700
4000	21	42	650	4600	770	8000

* Based on copper wire.

For Steel: Full $WK^2 = 0.9 \left[\text{Full } WK^2 \text{ (copper)} - \text{Empty } WK^2\right] + \text{Empty } WK^2$

For Aluminum: Full $WK^2 = 0.3 \left[\text{Full } WK^2 \text{ (copper)} - \text{Empty } WK^2\right] + \text{Empty } WK^2$

TABLE 3

DANCER CONTROL APPLICATION GUIDE

Consider Dancer Control when -

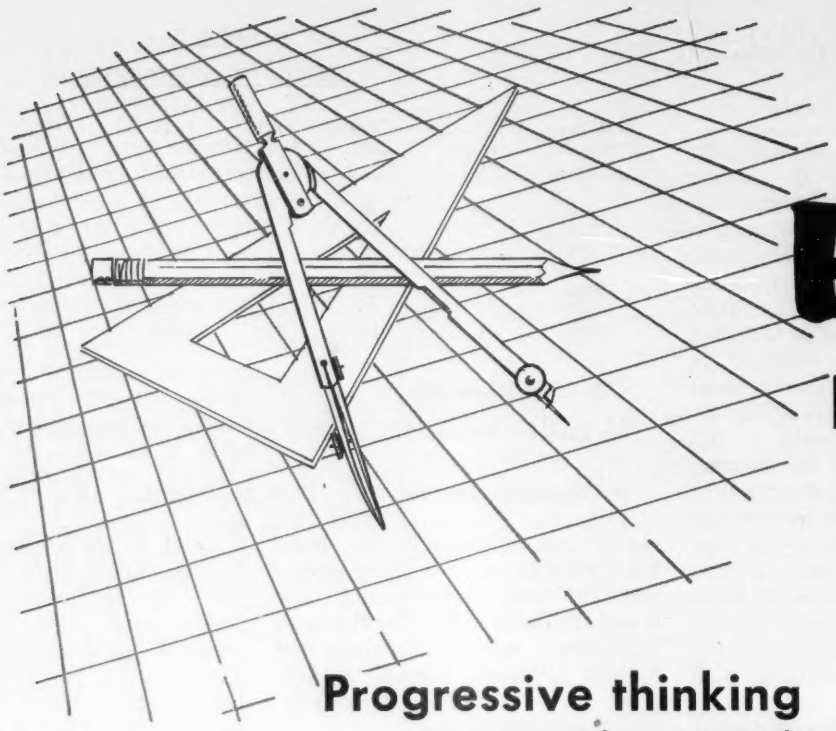
1. Wire is less than 0.060-inch diameter and wire speed is over 500 fpm.
2. Tension range of more than 5:1 is required.
3. Tension must be accurately maintained during acceleration and deceleration.
4. When maximum allowable tension is less than tension that may be exerted by inertia forces during acceleration and deceleration.

Typical Applications

Wire insulating extruder lines

Wire flattening mills

All types of tandem wire drawing machines; heavy, intermediate, and fine



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tinuous system can also be modified to obtain successful operation, if difficulties are encountered, at a much lower cost and in less time than many discontinuous systems.

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In the balance of this article the term "dancer roll drive" will only be used with reference to these two systems. See Table 3.

WHEN TO USE DANCER CONTROL

Although wire manufacturers generally prefer to use torque control, successful operation cannot be obtained with torque control in some cases, and in others very definite operating advantages can be obtained with dancer roll control. Dancer control may be advantageous, or necessary, under the following conditions:

1. **Friction and windage torque is the same order of magnitude as the torque required for minimum tension.**
2. **Minimum tension will be less than 20% of the maximum tension.**
3. **Torque due to inertia effects during transient speed conditions will be high relative to the maximum allowable tension torque.**

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Under any of these conditions the tension torque may be only a small portion of the total torque applied to the reel shaft. The dancer control drive then offers three major advantages over a torque control drive:

1. **Positive tension control is obtained at all times during starting, running, and stopping. With a torque system, it is frequently difficult, or impossible, to prevent excessive wire breakage during starting and stopping.**
2. **It will operate over a wide tension and linear speed range with more consistent tension control and less attention by the operator than a torque control system.**
3. **The quality and consistency of performance can be calculated and predicted with good accuracy while the performance of a torque system can only be estimated.**

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These advantages may be obtained with the dancer-controlled system because the wire tension is directly determined by the geometry of the dancer roll stand, the force exerted in the dancer roll and the number of loops of wire in the dancer, and is not affected by the torque required for friction, windage, traverse, and inertia.

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Figures 6 and 7 illustrate conditions that favor the use of a dancer control system. From Fig. 6 it will be seen that the tension tends to increase as the reel fills with wire on a torque control drive, primarily because of friction torque. This condition is accentuated on a constant-current drive by the operating requirements of the regulator, and it is most noticeable when the required tension torque approaches the friction and windage torque. The torque required for the traverse mechanism may also produce a large variation in tension. Thus, to obtain acceptable accuracy and effectiveness of tension control, it may be necessary to use a dancer roll system.

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In Fig. 7 it is assumed that the

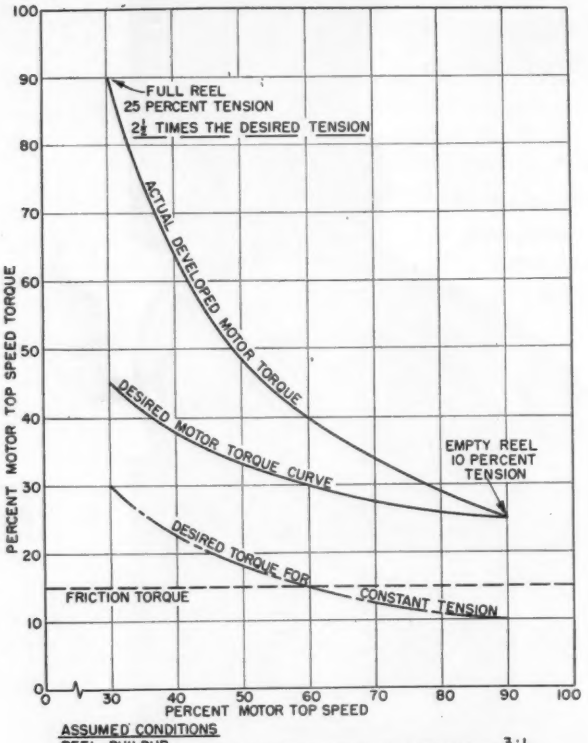
PERCENT MOTOR TOP SPEED TORQUE
PERCENT MOTOR TOP SPEED
FULL REEL
25 PERCENT TENSION
2½ TIMES THE DESIRED TENSION
ACTUAL DEVELOPED MOTOR TORQUE
DESIRED MOTOR TORQUE CURVE
EMPTY REEL
10 PERCENT
TENSION
DESIRED TORQUE FOR
CONSTANT TENSION
FRICTION TORQUE
ASSUMED CONDITIONS
REEL BUILDUP 3:1
MOTOR FIELD CONTROL (CONSTANT HORSEPOWER) RANGE 3:1
FRICTION LOSSES, PERCENT MOTOR BASE SPEED TORQUE 5 PERCENT
MOTOR ARMATURE CURRENT CHANGE REQUIRED TO VARY MOTOR FROM TOP SPEED TO BASE 5 PERCENT
TENSION CAPACITY OF DRIVE 100 PERCENT
EFFECT OF FRICTION LOSSES ON CONSTANT CURRENT DRIVE

FIG 6

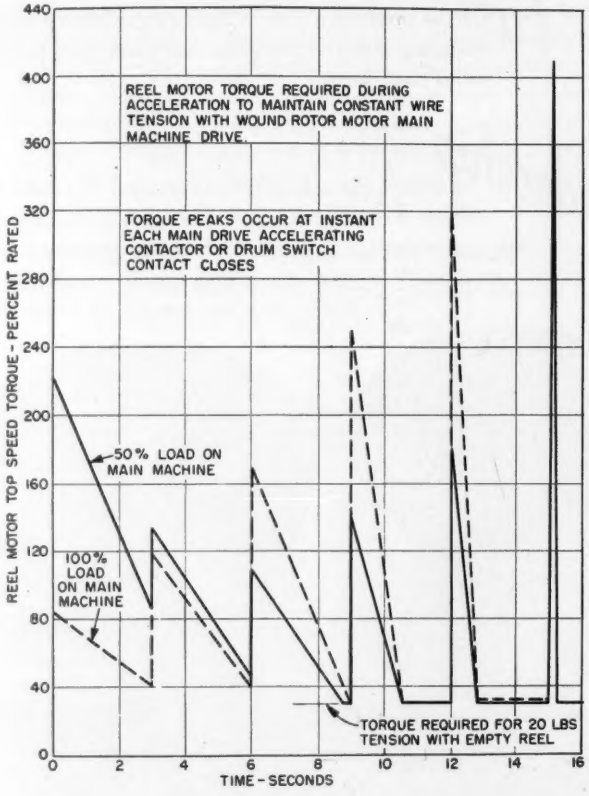
REEL MOTOR TOP SPEED TORQUE - PERCENT RATED
REEL MOTOR TORQUE REQUIRED DURING ACCELERATION TO MAINTAIN CONSTANT WIRE TENSION WITH WOUND ROTOR MOTOR MAIN MACHINE DRIVE.
TORQUE PEAKS OCCUR AT INSTANT EACH MAIN DRIVE ACCELERATING CONTACTOR OR DRUM SWITCH CONTACT CLOSES
50% LOAD ON MAIN MACHINE
100% LOAD ON MAIN MACHINE
TORQUE REQUIRED FOR 20 LBS TENSION WITH EMPTY REEL
TIME - SECONDS

FIG. 7

wire cannot slip during acceleration, and the main machine is started by shorting out successive sections of the secondary starting resistor with either drum switch or magnetic contactor control. The accelerating rate of the main machine varies almost instantaneously as each accelerating contactor or drum switch contact closes, and due to the inertia of the reel and reel motor, the torque applied to the reel shaft must vary at the same rate if constant tension is to be maintained. Since it is impossible to change the reel motor torque this rapidly, the tension will increase when the main drive accelerating rate is low and decrease on the main drive accelerating peaks. If the tension torque is high compared to the inertia torque (low wire speed, large wire) this change in tension will not be a problem, but if the tension torque is low compared to the inertia torque (high wire speed, small wire), the tension change may be sufficient to break the wire or allow slack wire to develop. In general, the use of a dancer control system will be justified when a tension range of more than 10:1 is required or the inertia torque that may be applied to the wire during starting or stopping is greater than the maximum safe tension for the smallest size wire.

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When the wire can be allowed to slip during starting and stopping, as is the case with most wet-type wire drawing machines, drive selection will seldom be limited by inertia considerations. Here the relative costs of the two systems must be compared considering the advantages of more accurate tension control, elimination of slip during starting and stopping, simpler machine operation, and more positive coordination between the main machine and the reel drives that can be obtained with dancer control in order to select the most suitable system.

Dancer Loop Storage Required

One of the most important factors in designing a dancer roll reel drive is the ratio of the maximum linear wire speed to the length of wire in the dancer storage loop. If this ratio is too high, the drive will not be stable. The condition is characterized by a sustained oscillation of the dancer roll that may become cumulative, with the dancer roll ultimately striking one of the extreme travel limits and breaking or snarling the wire. Knowing the ratio of maximum linear wire speed to dancer roll storage, and the other constants of the system, the drive designer can select equipment that will give stable operation. However, the drive cost may increase very rapidly with an increase in this ratio, so that it is desirable for the machinery builder to discuss drive cost with the electrical supplier before definitely selecting the dancer roll storage. The advantages of reduced storage can then be properly balanced against cost.

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Because of the many variables involved, each individual application must be analyzed to determine the minimum acceptable wire storage. However, the factors that influence wire storage can be identified, and the effect of each one noted:

***1. Linear wire speed.**
2. Change in wire storage from empty to full loop position.
3. Reel motor horsepower.
***4. Empty reel inertia.**
***5. Full reel inertia.**
***6. Reel build-up ratio.**

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The relative importance of these factors will vary with each installation, but an increase in any of the checked (*) factors will require either a more expensive drive or an increase in dancer loop storage.

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If the ratio of wire storage in feet to linear wire speed in feet per second is greater than 0.1 second, it is usually possible to design a stable drive. If the ratio is less than 1.0 second, it will almost always be necessary to use an amplifier to reduce the effects of both mechanical and electrical inertia. The cost of the drive will generally increase as this ratio is decreased, all other factors remaining the same. If minimum dancer storage is required, the drive will always require some type of amplifier, either electronic, rotating magnetic, or static magnetic. Since the addition of an amplifier not only makes the drive more expensive, but also more complicated, the advantages of reduced wire storage must be carefully considered.

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Typical installations include a 20-hp drive with an amplifier in the control circuit to reel wire at 2500 fpm on large reels using a dancer storage of 0.095 second, another 20-hp drive, also with an amplifier, for small reels at 5000 fpm and storage of 0.080 second, and a 5-hp drive without amplifier for small reels, 3000 fpm wire speed, and 0.83-second storage.

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In the capacity range required for most wire industry reel drives, the horsepower rating of the drive has very little influence on amplifier cost. Thus, the addition of an amplifier is relatively more expensive for smaller drives.

Effect of Main Machine Drive on Dancer Loop Storage

The main machine drive may have a major influence on the amount of storage required in the dancer roll and on the cost of the reel drive. The reel drive must not only operate successfully at running speeds within the allowable mechanical movement of the dancer roll, but must also accelerate and decelerate without reaching the extreme travel limits. Thus, the acceleration and deceleration characteristics of the main machine, assuming the wire cannot slip, have a major effect on the reel drive. If the reel drive is selected to provide satisfactory performance within the normal running speed range, it must also be checked for proper operation under the following conditions:

1. **Main drive maximum instantaneous accelerating rate.**
2. **Main drive maximum average accelerating rate.**
3. **Main drive maximum instantaneous decelerating rate.**
4. **Main drive maximum average decelerating rate.**

★ ★ ★

If the main drive uses an alternating-current motor, or a con-

stant-potential, direct-current motor, the accelerating rate will be very erratic as illustrated in Fig. 7. It will also change as a function of the load on the main machine. As can be seen from Fig. 7, the maximum accelerating rate becomes very high at light load. If a gear shift is used to change the linear finishing speeds, the accelerating rate will also vary according to the speed selected.

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If minimum dancer roll storage is to be obtained, the take-up reel drive must have sufficient torque capacity to accelerate at the maximum average rate of the main machine. Even in this case, additional storage might be required to insure that the extreme travel limits of the dancer roll would not be reached during the most rapid portions of the main drive acceleration period. This may require a very large reel motor. If it is necessary to accelerate a partially filled or nearly full reel, an even larger reel motor may be needed. It may be possible to limit the accelerating torque required by the reel by increasing the storage in the dancer roll so that it can accumulate wire during acceleration. However, with the wire speeds that are commonly used for wire drawing in modern mills, this may not be practical for any reasonable reel drive accelerating rate.

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As an example, consider a wire drawing machine finishing at 5000 fpm. If the main machine reaches full speed in five seconds and the spooler drive reaches full speed in ten seconds, the dancer roll would have to accumulate 210 feet of wire.

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From the standpoint of operation, the best solution to this problem is to use an adjustable-voltage drive for the main machine with timed acceleration and deceleration. The starting and stopping rates can then be selected in accordance with the capacity of the take-up reel motor, and they can be made independent of the main machine load. In general, reel motors selected to provide adequate tension and stable operation can accelerate empty reels to maximum speed in from ten to twenty seconds.

Problems Caused by Rapid Stopping

Because of the high inertia of a full reel, reel motors frequently cannot stop a full reel as rapidly as they can start an empty reel. This is quite undesirable, since most wire manufacturers prefer to stop as rapidly as possible. The addition of a brake is the only economical means of obtaining rapid stopping. Brakes for reel drives should be mounted on the reel shaft, except for very low-speed applications. The torque required to overcome the reel inertia is seldom less than twice the rated motor torque and may be ten times the rated torque, or more. If a motor-mounted brake is used, this extremely high torque must be transmitted through the motor shaft and coupling and may result in a disproportionate increase in size and cost of the reel motor.

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The addition of a brake does not create any major problem when used for emergency stopping. However, on normal stopping, the brake must be used to maintain the position of the dancer roll to prevent slack or broken wire. Since this is the equivalent of a dancer-controlled clutch drive, it is an inherently unstable control system, although, by careful design of the brake control and proper brake selection, satisfactory operation can be obtained. While it will not always be possible, it is desirable to use the reel motor to assist the brake.

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Electrically-set mechanical brakes are most suitable for this purpose. Eddy current brakes may be used, particularly when very high torque is required, but they have several disadvantages: the brake control is more expensive, they make the dancer system more difficult to stabilize, and their torque capacity drops to zero at zero speed.

Types of Dancer-Controlled Adjustable-Voltage Drives

When direct-current motors are used for dancer control reel drives, they are normally supplied from an adjustable-voltage, direct-current generator. Adjustable-voltage control is required for starting and stopping and may also be required to obtain the necessary linear speed range. There are three arrangements that may be used for this type of drive:

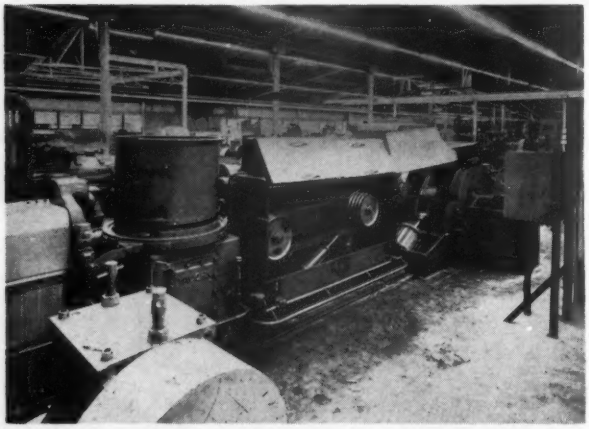

Photo A—Dancer-controlled reel drive with wire-drawing machine. * *

Photo B—Dancer-controlled single motor, dual reel, take-up stand. * * *

1. **Motor field control for reel build-up speed range, with armature voltage control for starting, stopping, and linear speed range.**
2. **Armature voltage control for both reel build-up and linear speed range, with dancer control limited to the build-up speed range, and a separate control circuit for linear speed range.**
3. **Armature voltage control for both speed ranges with complete dancer control.**

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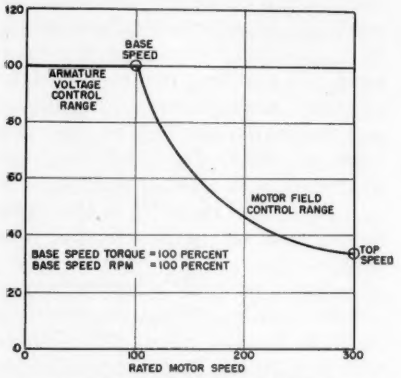
The horsepower rating of the reel motor may vary quite widely, depending on the arrangement used, although the physical size of the motor will not vary to the same degree. This results from the fact that essentially the same maximum torque must be available regardless of the system used, and the physical size of a motor is primarily determined by the torque capacity. With full armature voltage control the maximum torque is available over the complete speed range while the torque capacity is reduced above base speed when using both motor field and armature voltage control (See Fig. 8.)



NOTE: CURVE NEGLECTS TORQUE LIMITATION IMPOSED ON MOTOR BY HEATING CONSIDERATIONS AT LOW SPEED IN THE ARMATURE VOLTAGE CONTROL RANGE

DIRECT CURRENT MOTOR TORQUE CAPACITY

FIG. 8

In most cases, the drive application engineer should be allowed to select the arrangement that will best meet the operating conditions established by the machinery builder or wire manufacturer at the lowest possible cost. The particular arrangement used concerns the machinery builder or wire manufacturer in only two respects:

1. **With either the first or second arrangement, the dancer moves from approximately full-loop position with minimum reel diameter to approximately empty-loop position with the maximum reel diameter, and is essentially independent of the linear wire speed. With the third arrangement, the dancer roll movement varies as a function of both the reel diameter and the linear wire speed; it moves farther from an empty reel to a full reel at the maximum linear speed than at the minimum linear speed.**
2. **The third arrangement provides the simplest, lowest cost, dancer-controlled drive, but it may be necessary for the operator to place the dancer roll in the proper position before starting the drive.**

Design of Dancer Roll Stand

It was pointed out earlier that tension control is not a function of the drive in a dancer control system but is determined by the design of the dancer roll stand. Therefore, it is important that all factors influencing the tension be considered in designing the stand.

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Most stands will be designed with the sides of the storage loop parallel. If they are not, the wire tension will increase as the reel diameter increases and the dancer roll moves toward the minimum storage position unless a special dancer loading system in used. In some cases, the advantages of compact design and convenient threading offset a moderate increase in tension from non-parallel loop sides.

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Whenever possible, multiple loops should be used rather than a single loop. With this arrangement, the height of the dancer stand can be kept to a minimum, making threading more convenient. By keeping the weight of the pulleys small, relative to the weight of the movable carriage, multiple loops reduce the effect of carriage friction and inertia on wire tension. When very light tensions are required, the tension may be limited by the minimum force that it is practical to apply to the dancer roll and by the torque required to turn the rheostat or cam used to translate dancer roll movement to an electrical signal. The minimum size of these components may be limited by strength and durability considerations rather than by the required tension. With a fixed lower limit on these factors, the mechanical advantage of multiple loops will reduce the minimum wire tension.

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Some objections may be raised to multiple loops on the basis that they require additional threading time. However, the threading time on most wire processes is so small, relative to the running time, that this is seldom an important consideration.

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When designing a dancer roll stand, particularly for high ratios of maximum linear wire speed to dancer storage, it is very desirable to allow for the addition of extra loops. This is a simple, economical means of avoiding serious difficulty.

★ ★ ★

Although wire tension is not influenced by the drive at constant wire speed, the drive design may have an indirect effect due to the inertia of the dancer roll. This condition would develop when using stepped acceleration of the main machine or during a "flying transfer" on a dual reel drive. Here the dancer roll may reach a position calling for a large change in reel motor speed. If the reel motor accelerating rate is not limited, substantial tension may be applied to move the dancer roll to the correct position. In some cases, it will be possible to limit the reel motor accelerating rate to control this condition, but this may conflict with the requirements for stable operation. Because of this consideration, it is more desirable to increase the number of loops in the dancer roll and reduce the inertia of the movable carriage.

★ ★ ★

Dual reel drives are frequently used on wire insulating extruder line drives. With high wire speed and small wire, dancer inertia must be considered. When the full reel and empty reel are driven by the same shaft, the wire speed leaving the dancer roll will drop almost instantaneously by the build-up ratio of the reel during a "flying transfer." This operation usually requires an "accumulator"

(*Please turn to page* 1291)

New Type Plating Barrel for Automatic Handling of Large Batches

by N. Ransohoff, Chairman of the Board
N. Ransohoff, Inc.
Hamilton, Ohio

The subject of this paper is the description of a new labor and space saving piece of equipment for electro plating.

★ ★ ★

The machine has particular application where comparatively large batches can be profitably handled at one time. The limitation on previously designed plating barrels has been the fact that they must be built of non-metallic material with drilled holes to permit the electric current to pass from the anodes to the cathodic work inside the barrel. This has always imposed a limitation on the size of the barrel due to the structural limitations of the material as well as on the amount of area available for the current to pass through the shell of the barrel. In our construction the barrel is built of rubber lined steel mounted above the tank in which the electrolyte is stored. The electrolyte is pumped from the tank into the drum and circulates back to the tank. This electrolyte is handled by a packless vertical centrifugal pump of our own design. The circulation of the electrolyte seems to have several advantages, one, filtration during circulation and, more important, the possibility of installing refrigerating coils in the tank to maintain optimum temperatures of the electrolyte at high current densities. This permits extremely accurate control of the solution temperature. In designing the machine we were not attempting originally to improve plating characteristics but rather to design a unit in which large batches could be loaded and unloaded and passed through the pre-plating and after-plating processes with a minimum of labor. This has been accomplished by designing the drum along the lines

N. Ransohoff

Mr. Ransohoff prepared this paper for presentation at the Annual Convention of The Wire Association in Chicago, Ill., November 14-17, 1955.

Founder of the company 40 years ago, Mr. Ransohoff's inventive genius is responsible for the development of many types of equipment and processes for the surface treatment of metals. In the wire industry, the company is widely known for its equipment for the cleaning, weighing and packaging of nails.

that we have followed in automatic loading and unloading cleaning machines for the last 39 years. The design of our automatic loading and unloading batch type machines is such that the work is held in the drum when rotating in one direction and automatically discharged when rotating in the opposite direction. In adapting this design to a plating barrel quite a few problems had to be overcome. The anodes are contained in a steel cylinder extending through the center of the barrel and of sufficient diameter to dip into the electrolyte. This cylinder rotates with the barrel and is entirely insulated to prevent direct contact with the work. The anodes are cubes or balls rolling loose inside the anode cylinder. This action prevents the formation of bubbles and keeps the anodes clean. The current is carried to the work through buttons on the periphery of the drum which are so wired that the current only flows through them when they are in contact with the work. This plating barrel in actual operation is one unit of a complete line in which a batch of work can be charged at one end and come out the other end completely finished.

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Referring to Figure 1, the first unit is one of our automatic loading and unloading Ransomatic tumbling barrels. In this unit the work is tumbled when the drum rotates in one direction and automatically unloads when the drum rotates in the opposite direction. During the tumbling operation the work can be automatically subjected to as many processes as necessary, the machine being so designed that each processing solution automatically returns to its own tank so that, for instance, the process may consist of pickle, rinse, neutralize and rinse all in the same drum and all automatically controlled. If pickling is not necessary, of course, the multiplicity of tanks is not required. Since the cleaning cycle is usually about 20 minutes and the plating cycle approximately 1/2 to 1-1/2 hours, one Ransomatic will be set up with one or a number of plating barrels. Therefore, the work is discharged from the cleaning barrel onto a cross conveyor which will charge it into any one of two or more plating barrels which is empty at the time. The work remains in the plating barrel rotating in the tumbling direction as long as necessary to acquire the thickness of plate required and is then automatically discharged by reversal of direction of the barrel. The barrels each discharge onto one cross conveyor which in turn charges the work into a continuous drum type ma-

(*Please turn to pages* 1277 *and* 1278)

Progressive Work-Hardening and Reannealing Of Five Brands of High Conductivity Copper

by

M. V. Yokelson
Research Metallurgist
General Cable Corporation
Bayonne, New Jersey

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Brooklyn, New York

Introduction

Copper for electrical conductors must, of course, have a high electrical conductivity. To insure this, the metal is purified to a high degree. The refining procedures whereby the purification is accomplished are not identical in all plants, principally, because the raw materials differ in content and kind of impurity elements. A small portion of these remains in the refined copper, the residual quantities depending upon the details of the refining practice employed. As a consequence of depending upon the same source of raw materials and using a rigidly standardized refining practice, high conductivity copper from every refinery habitually contains a rather definite pattern of impurity content. Thus, the "brand" of the refinery stamped on copper shapes serves to identify both the refinery which produced them and the nominal content of impurities.

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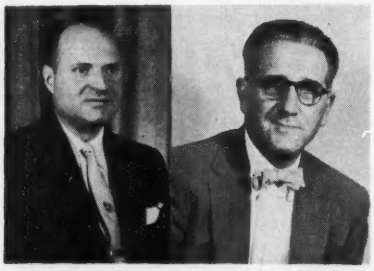
All the high conductivity brands differ among themselves only slightly in their total copper content, electrical conductivity, and other properties such as behavior during cold plastic forming; the thermal stability of their work-hardened state, however, may differ considerably. These differences are now well recognized and are being pressed into service. Brands that work-harden more readily and/or have a high thermal stability of their work-hardened state are better suited for applications where these features are of advantage, for example in overhead transmission cables, commutators, and hot-dip tinned hard-drawn wire. In the manufacture of enameled magnet wire, however, noted advantages are gained when brands characterized by a low thermal stability of their work-hardened state are used.



M. V. Yokelson Dr. M. Balicki

This paper is based largely on a thesis submitted by one of the authors in June, 1951, in partial fulfillment of requirements for a Master of Metallurgical Engineering degree at Polytechnic Institute of Brooklyn. It has been prepared for presentation at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955.

Mr. Yokelson, a graduate of both the College of the City of New York, and Polytechnic Institute of Brooklyn, holds B. Ch. E. and M. Met. E. degrees. During W. W. II he was a Naval Ordnance Engineering officer. He joined General Cable in 1948.

Dr. Balicki was born and educated in Poland. From the Cracow School of Mines and Metallurgy he received degrees of Dipl. Met. Eng. and D. Tech. Sciences. He worked in Poland from 1932 to 1939, in England from 1941 to 1947, following which he joined the Institute.

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From the above remarks it is clear that the industries which process or use high conductivity copper need to know in some detail the work - hardening - reannealing cycle of every brand of copper available. Not only are the "natural" brands of interest but also their high-thermal stability variants produced recently by small additions of alloying elements. The technical literature ([1, 2, 3]) does contain some information about these brands and the files of numerous research laboratories undoubtedly contain a great deal more. However, all this information, valuable as it may be, appears to be limited in scope and assembled under too diverse experimental conditions to be of real value for strict, objective discrimination.

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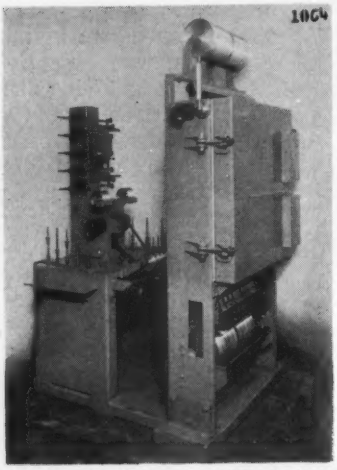
One of the aims of this paper is to initiate such a survey of the work-hardening-reannealing cycles of various brands of refined copper. Another one, is to indicate how rapidly such a survey can be completed, or kindred problems solved, by employing modern approach, involving progressive work-hardening and progressive reannealing.

Material

Because at the root of the different behavior of various brands of copper on cold-working and on exposure to the action of thermal energy are the differences in the kind and amount of impurity elements, it was considered highly advisable to test copper of the highest purity. Such a copper has been made available for the purpose by the American Smelting & Refining Company. Against this spectroscopic purity standard it was decided to study Oxygen Free High Conductivity Copper, two high conductivity tough pitch coppers and a high thermal stability copper known as "Tensilok", pro-

Patented Aug. 3, 1943

Glass Insulation Wire Covering Machine No. 805.
With Electric Heated Varnish Baking Oven.



M-10 Enameling Machine No. 1064. Built especially to apply enamel to extra fine diameter wires.

EST. 1855 AIMCO INC. 1915

"American" AIMCO INSULATING MACHINERY COMPANY

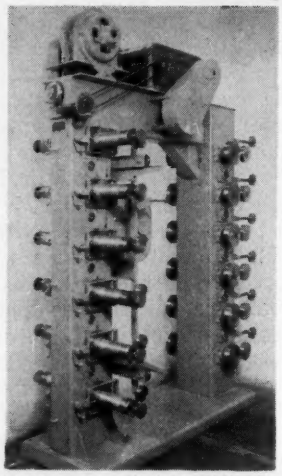
REG. U.S. PAT. OFF.

FAIRHILL AND HUNTINGDON STREETS

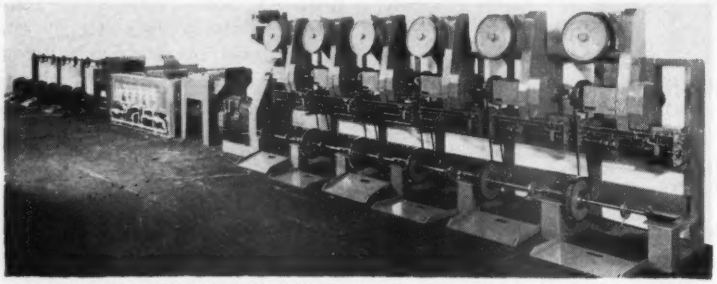
PHILADELPHIA 33 PENNSYLVANIA U.S.A.

WE SPECIALIZE IN MACHINERY FOR:
WIRE DRAWING, ENAMELING,
TINNING, INSULATING, TAPING,
GLASS-COVERING, PANNING,
AND ALLIED MACHINERY

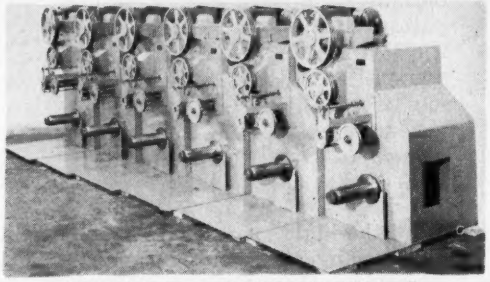
ESTABLISHED IN 1855
1955 IS OUR CENTENNIAL



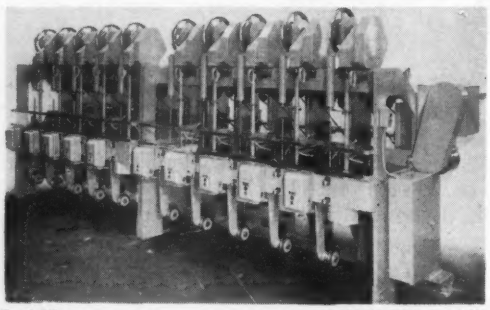
12 Unit Take-up Stand No. 1041. For use in wire tinning outfits, etc.



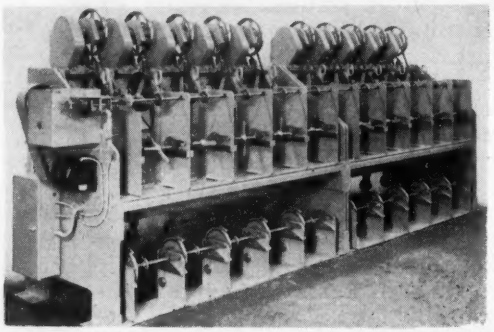
Heavy Wire Tinning Outfit No. 1010. With Gas Heated Tinning Tank and Automatic Heat Control.



Multiple Wire Take-up No. 1049. 6 individual units, each Reel-arbor torque motor driven. For use in wire tinning outfits, etc.



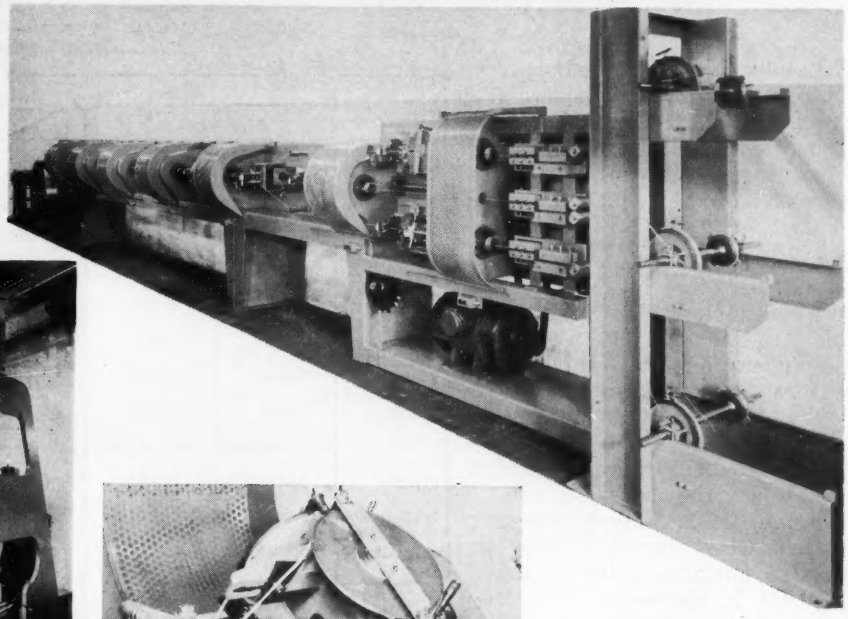
Front View

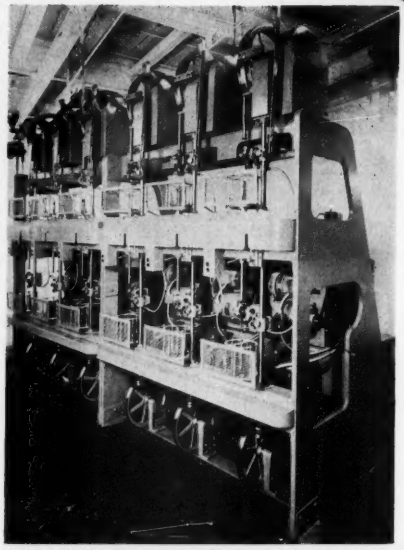


#2S-10-MBB Insulation Winding Machine No. 1077.
Applies a single cover to 10 lines of wire.

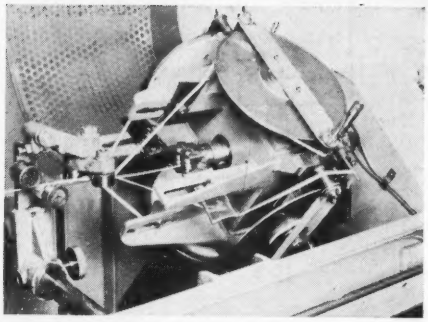
Rear View

4 M-T-BB Taping Machine No. 1105. Arranged for individual wire double taping, then combining and multiple tape covering.





Double Taping Machine No. 1107. Applies 2 tapes to each of 6 round or flat wires.

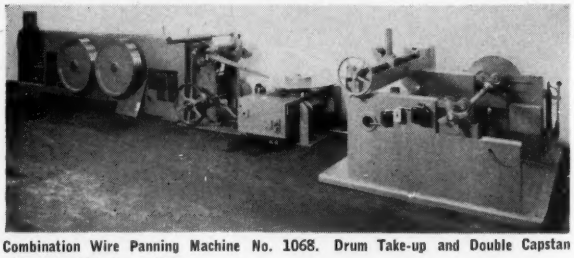


Quadruple Taping Head No. 889.

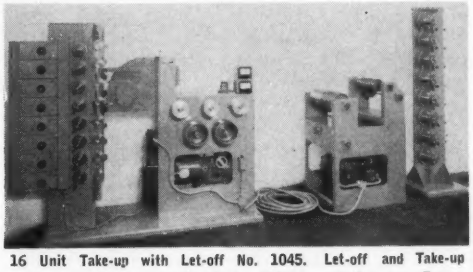
EST. 1883 AIMCO INC. 1918

"American" INSULATING MACHINERY COMPANY

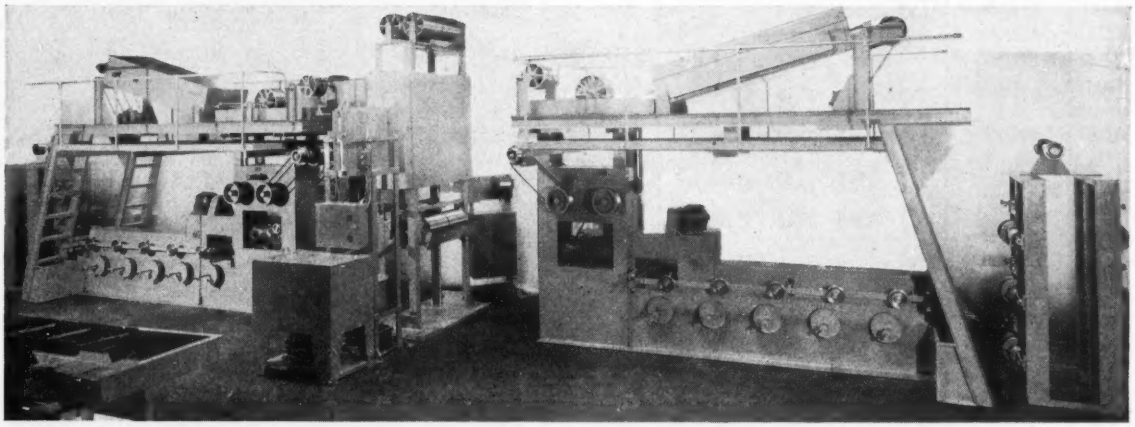
REFER TO NUMBERS



Combination Wire Panning Machine No. 1068. Drum Take-up and Double Capstan with Adjustable Speed Drive.



16 Unit Take-up with Let-off No. 1045. Let-off and Take-up capstan speeds are synchronized. Take-up spindles are Torque Motor driven.



Wire Enameling Machine outfit No. 997. With Pre-annealer, Storage, Circulating and Filter System for Enamel. Oven is higher than shown and is shortened to show top sheaves.

duced by the General Cable Corporation.

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The composition of the brands of copper used in this investigation is given in Table 1. The table also contains designations of each brand subsequently employed in this paper.

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Commercial brands "A", "B", "C", and "D" were taken at random in form of wire bars from the processing line of the General Cable Corporation. They can therefore be considered as typical.

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All the wire bars were processed according to the schedule condensed in Fig. 1. This produced ultimately wires having different degrees of work-hardening at the same 0.081 in. diameter. Table 2 contains data pertaining to the starting material after penultimate annealing. The table reveals some differences in properties between

TABLE 1

Chemical Composition of Copper Tested
(Percent by Weight)

Element	Brand "A"	Brand "B"	Brand "C"	Brand "B" ("Tensilek")	Brand "B" (High Purity)
Oxygen	0.030	nil	0.030	Detailed chemical composition not available. Conforms fully to ASTM B5-43.	nil
Iron	0.0015	0.0009	0.0007		<0.00007
Antimony	0.0007	0.0007	0.0001		<0.0001
Lead	0.0008	0.0003	0.0004		<0.0001
Tin	0.0003	0.0001	<0.0001		<0.0001
Nickel	0.0015	0.0015	0.0001		<0.0001
Bismuth	0.0002	0.00002	<0.00001		<0.00001
Silver	0.0021	0.0014	<0.00003		<0.00003
	(0.63 oz/ton)	(0.42 oz/ton)	(<0.009 oz/ton)		(<0.009 oz/ton)
Arsenic	0.0007	0.0004	0.0002		<0.0002
Tellurium	0.0002	0.0001	0.0001		<0.0002
Selenium	0.0001	<0.0001	<0.0001		<0.0001
Sulfur	0.0013	0.0037	0.0013		<0.0001
Copper (by difference)	99.961	99.991	99.967		99.999 min

*Nominal Composition

TABLE 2

Diameter, Tensile Strength, Elongation and Grain Size of Copper Prior to Final Work-Hardening

Diam. (in.)	% Red. in Area when Drawn to 0.081 in. diameter	Tensile Strength (1000 psi) A	B	C	D	P	Elongation (% in 10 in.) A	B	C	D	P	Grain Size (mm.) A	B	C	D	P
0.081	0.0	35.1	34.5	33.7	34.9		33.8	38.0	33.8	34.0		0.015	0.020	0.015	0.020	0.025
0.083	4.8	34.8	33.9	33.7	35.0		36.2	34.8	36.8	36.0		"	"	"	"	-
0.086	11.4	34.6	34.1	34.0	35.3		39.3	33.3	34.1	36.4		"	"	"	"	-
0.088	15.3	34.3	34.4	33.5	35.2		38.0	32.5	34.7	35.4		"	"	"	"	-
0.091	20.8	34.3	34.9	34.5	35.1		35.5	32.5	31.0	35.4		"	"	"	"	0.025
0.096	27.9	34.9	34.3	33.6	35.3		36.0	35.2	35.6	28.5		"	"	"	"	-
0.102	37.0	34.8	34.3	33.7	35.3		34.5	36.5	35.2	37.6		"	"	"	"	0.020
0.113	48.5	35.5	35.3	34.6	35.4	Not Determined	35.8	33.5	35.9	36.5	Not Determined	"	"	"	"	0.020
0.128	60.1	35.1	35.2	34.5	35.2		36.0	35.3	37.2	38.0		"	"	"	"	-
0.144	68.3	35.4	34.9	34.2	34.6		35.5	37.3	40.6	37.0		"	"	"	"	-
0.161	74.7	34.9	34.4	33.6	34.3		35.2	37.3	39.6	36.0		"	"	"	"	0.020
0.204	84.8	33.9	33.3	32.9	33.0		38.0	38.1	38.5	42.0		"	"	0.020	"	0.020
0.256	90.0	32.3	32.6	32.5	32.7		33.2	38.2	41.2	40.5		"	"	"	"	-
0.313	93.4	32.2	31.9	31.5	33.8		44.5	44.3	40.0	36.5		"	"	"	"	0.020

NOTE: All samples of commercial brands met the tensile strength and elongation requirements of ASTM Specification B3-54T, "Soft or Annealed Copper Wire".

the brands. These differences are expected since the brands vary in composition. The table also reveals that wires of every brand, at the stage just prior to final drawing, show no or only minor differences both in the grain size and tensile properties. Consequently, all the wires of each brand from which final samples had been obtained by drawing, can be considered as basically identical in structure and tensile properties. This finding is of importance for future comparison of the behavior of wires work-hardened to different degree.

* * *

In the final drawing operation tungsten carbide dies, tallow lubricant, a drawing speed of 160 fpm and single AWG reductions were employed. Approximately 150 feet of commercial brand wire and 25 feet of "P" copper wire were prepared for each degree of cold work. To avoid the possibility of mixing the wires, at any one time samples were cut from one coil only and

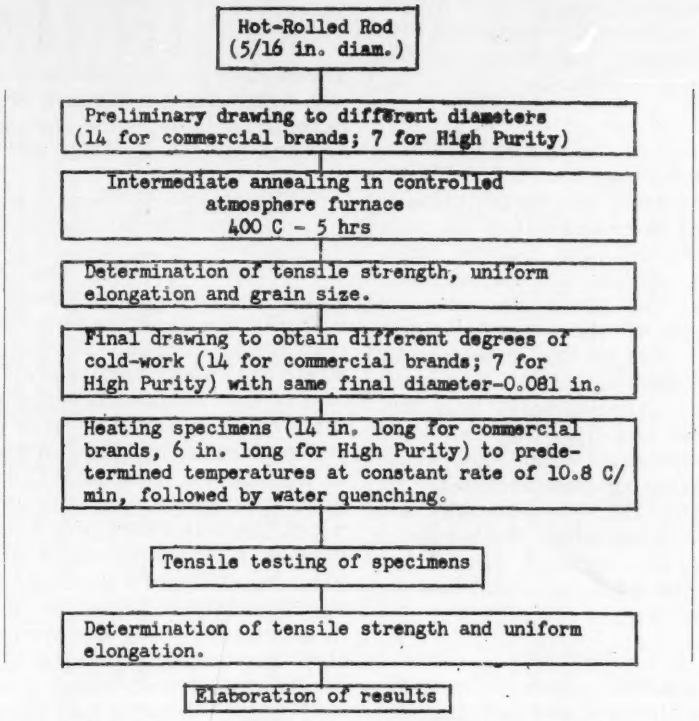
Hot-Rolled Rod
(5/16 in. diam.)
Preliminary drawing to different diameters
(14 for commercial brands; 7 for High Purity)
Intermediate annealing in controlled
atmosphere furnace
400 C - 5 hrs
Determination of tensile strength, uniform
elongation and grain size.
Final drawing to obtain different degrees of
cold-work (14 for commercial brands; 7 for
High Purity) with same final diameter-0.081 in.
Heating specimens (14 in. long for commercial
brands, 6 in. long for High Purity) to prede-
termined temperatures at constant rate of 10.8 C/
min, followed by water quenching.
Tensile testing of specimens
Determination of tensile strength and uniform
elongation.
Elaboration of results

Figure 1 - Preparation of Copper for Testing

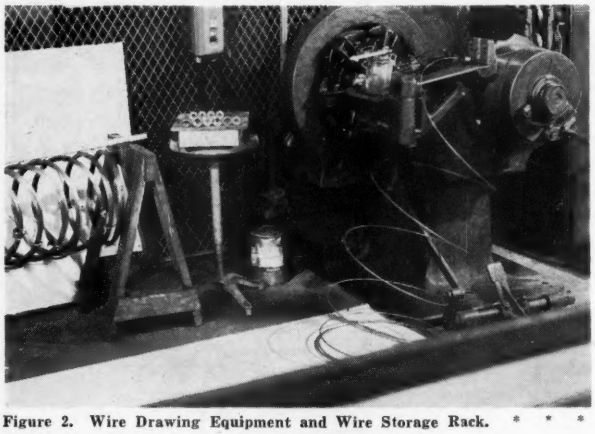

Figure 2. Wire Drawing Equipment and Wire Storage Rack. * * *

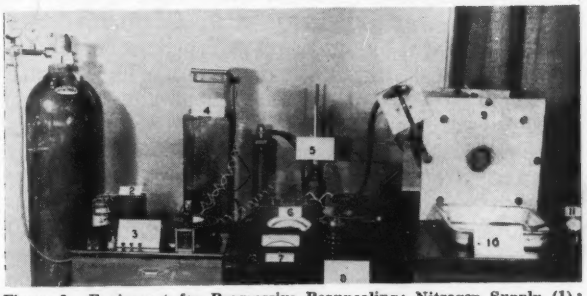

Figure 3. Equipment for Progressive Reannealing: Nitrogen Supply (1); Standard Cell (2) for L. and N. Type K. Potentiometer (3); Galvanometer (4); Ice-Water Cold-Junction (5); Ammeter (6); Voltmeter (7); and Autotransformer ("Variac") (8) for control of power input to reannealing furnace (9); Quenching Dish (10); Timer (11). * * * *

their ends immediately flattened and marked with an appropriate code. The drawing equipment and the finished wire storage rack are shown in Fig. 2.

Annealing and Tests

The apparatus for progressive reannealing of the samples is shown in Fig. 3. This consists primarily of a specially designed furnace, one of the features of which is a nitrogen flushed temperature equalizing copper block 15 in. long. This contains 30 periferally located compartments, each providing adequate accommodation for two wire specimens. The effective sample capacity of the furnace is 50 wires per run, because four compartments are used for preheating of the nitrogen and one insertion of the thermocouple. During annealing, the samples are swept with a preheated, closely metered, stream of nitrogen, the oxygen content of which is reduced by contact with copper shavings placed in the preheating compartments. The power input to the furnace is controlled so that the furnace develops a 10.8 C/minute rate of heating in the 100 to 550 C temperature range. The temperature is measured with an iron-constantan thermocouple which has been carefully calibrated at melting point of ice; boiling points of water, naphthalene and sulphur; as well as at the freezing point of pure lead. The cold-junctions during the measurements are kept at melting-ice temperature, the hot-junction being placed in the middle of a sample compartment. The front part of the thermocouple compartment is permanently plugged with two half samples in order to simulate better the heating conditions in the sample compartments. For reading the thermal emf a Leeds & Northrup Type K potentiometer is used.

The standard cell of this instrument is frequently compared with one recently calibrated by the Bureau of Standards.

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In most of the runs 50 specimens are loaded into the furnace. When the required temperature is reached two wires out of the same compartment are quickly withdrawn, cooled, and immediately tested. To insure an adequate coverage of the recrystallization range with the experimental points, wire specimens from each coil are annealed in at least two runs. In the first one, the wires are withdrawn when they reach the following temperatures: 20, 100, 150, 175, 200, 250, 350, and 400 C. Withdrawal temperatures for the next run are then chosen from the pilot curve outlined by the preliminary results.

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As structure change indexes, the tensile strength and uniform elongation were chosen. The conversion of the breaking load (pounds) into the tensile strength (psi) was greatly facilitated by uniformity of wire diameter (d_o). For arriving at the values of uniform elongation "a" the diameters "d" of the fractured specimens were measured at a distance from the fracture approximately equal to five times the original diameter "d_o". From these measurements the uniform elongation was obtained from the known relation: $a = \left[\frac{(d_o)^2}{d} - 1 \right] 100$

The arrival at the values of "a" was facilitated by advance preparation of a table which correlated "d" and "a" for $d_o = 0.081$ in.

Results

The rate of heating (m) with which the samples are heated affects the results in the progressive reannealing method. To demonstrate the order of differences due to the rate of heating employed, samples of copper "A" with 93.4 per cent reduction were annealed at m=2.3, 7.8, 10.8, and 13.9 degrees centigrade per minute of which the rate 10.8 C/minute was used as a standard one in all regular runs. Figure 4 represents the results obtained. The main curves in this figure which are "progressive reannealing characteristics" of the wire tested reveal a very well defined drop. It may be seen in this figure that heating rates lower than the standard 10.8 C/minute shift the drop in the characteristic curve to the left, and the higher rate to the right, with regard to the basic position. Except in the case of the very low heating rate, the displacements are not very large, but quite significant. The inset in this figure contains the actual heating curves determined during these runs. It will be seen that those curves are linear in the temperature range of interest.

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The numerical data secured on testing all the brands of copper have been collected in Tables 3 - 7 to provide a direct access to accurate figures that are necessary for any other quantitative analysis of the results. In these tables, the rows of data in line with 20 C contain information regarding the tensile strength and elongation changes due to cold-drawing alone. The subsequent rows contain test data obtained on wires cold-drawn to the reduction indicated and subsequently heated at a rate of 10.8 C/minute to temperatures shown in the first column.

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Tabular representation of results, advantageous as it is for quantitative work, does not provide the best picture of changes that occur. To provide such a direct visual representation of "progressive reannealing characteristics" space-diagrams shown in Figures 5-14 have been constructed. These correlate very well the tensile strength and elongation of every brand of copper tested, with the degree of cold-deformation and the temperature of exposure on progressive reannealing. They thus form a valuable supplement to the tables.

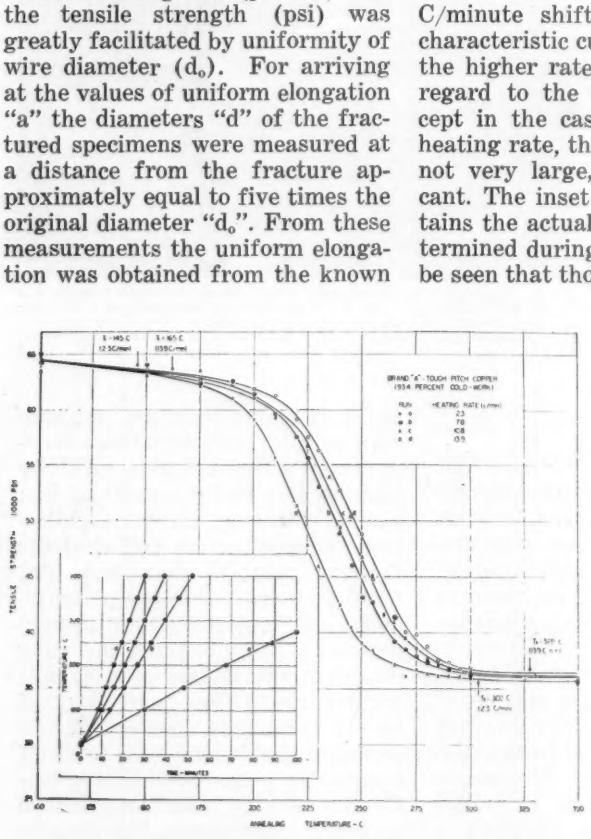

Figure 4.—Demonstration of the Effect which the Rate of Heating has on Progressive Reannealing Characteristics.

The inset shows the heating curves developed by the furnace.

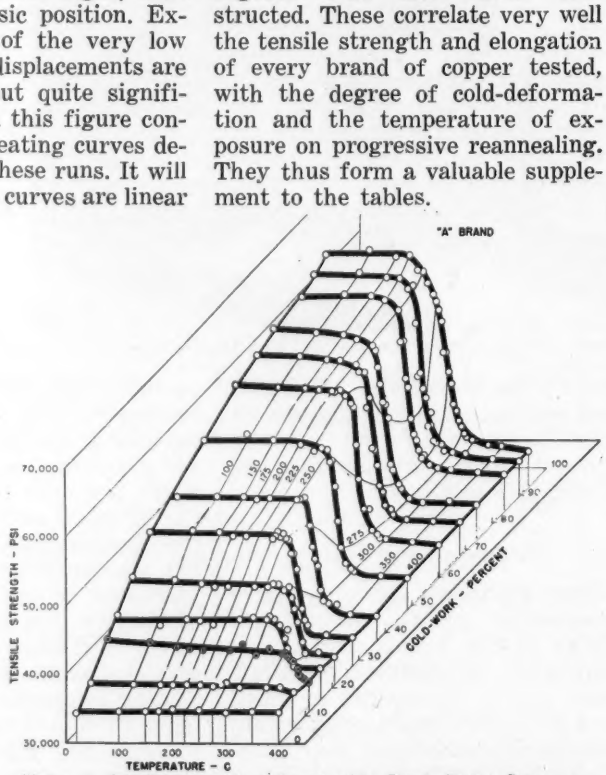

Figure 5. Tensile Strength of Brand "A" (Tough Pitch) Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute.

BRAND "A" - TOUGH PITCH COPPER

Tensile Strength (ts, in thousands of psi) and Uniform Elongation (e, in percent) in Relation to Cold-Work and Annealing Temperature

Degree of Cold-Work (%)	0.0		4.8		11.4		15.3		20.8		27.9		37.0		48.5		60.1		68.3		74.7		84.8		90.0		93.4	
Annealing Temperature (C)	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e
20	34.2	42.8	36.8	37.8	40.6	21.5	42.5	16.0	46.0	9.5	49.6	6.2	51.0	4.5	54.8	4.0	58.8	4.0	59.1	4.4	60.6	3.8	61.0	3.3	61.8	3.3	63.4	3.3
100	34.5	45.0	36.6	33.8	40.2	20.0	41.1	18.5	45.6	9.3	49.9	8.5	51.1	3.8	55.7	3.3	57.7	4.4	59.0	3.3	59.9	3.3	61.4	3.3	62.1	5.0	64.0	3.3
150	34.5	47.8	36.6	34.4	39.5	22.8	41.9	14.3	44.9	10.8	49.6	7.0	51.1	4.0	54.7	3.8	57.5	3.3	58.4	3.5	59.7	3.3	61.1	4.4	61.4	3.0	63.1	3.3
175	34.5	44.5	36.5	36.8	39.1	29.0	41.6	18.5	44.3	12.4	49.1	7.8	50.7	4.0	54.6	3.3	57.3	2.5	58.3	4.0	59.0	4.4	60.5	3.3	61.3	4.4	63.4	3.5
190																									59.8	3.3	61.2	5.0
200	34.9	44.3	36.5	36.8	39.0	28.0	41.1		44.3		49.1	7.5	50.9	3.8	54.1	3.5	57.1	2.5					59.2	3.8	60.2	4.4	61.0	4.4
205																	57.0	4.5	57.7	19.5	58.1	4.4	54.5	7.8	54.9	8.6		
210																			56.6	4.4	57.0	4.0	54.6	5.8	47.2	7.8	59.4	7.8
215																	57.2	4.3			55.0	20.8	49.1	14.3	47.7	13.0		
220																			56.6	5.0	52.5	5.8	47.9	20.0	45.4	18.5	57.8	7.8
225			36.6	42.0											53.2	2.4	56.4	2.5	51.4	9.5	49.9	11.5	43.3	24.0	44.1	20.8	56.7	5.0
230																			52.9	8.0	49.6	14.0	41.1	35.0	40.0	32.0	55.6	6.0
235																	55.3	5.0	45.6	16.0	47.6	12.4	40.2	29.5	40.1	32.5	53.9	9.5
240															53.6	4.0	54.7	2.5	45.5	22.0	40.9	26.0	38.8	34.8	37.9	27.5	49.4	15.0
245																	49.3	14.7	43.1	25.0	40.1	29.5	37.5	44.3	37.6	50.7	49.5	17.5
250	34.7	48.5	36.4	34.0	39.1	28.0	42.3	16.0	44.3	13.0	48.6	8.6	50.7	7.5	53.3	5.0	44.3	12.6	48.2	32.5	37.6	42.0	38.0	44.3	38.4	34.8	46.7	16.1
255											49.1		50.8	5.0	51.5	5.8			39.3	37.5	38.0	41.0			37.4	42.0	44.9	17.5
260											49.7		50.8	6.5	51.7	7.6	40.0	29.5	37.3	48.5	37.4	47.8	36.6	47.5	36.4	44.3	41.9	26.4
265			36.4	42.0							48.9		51.0	17.5	48.0	10.8											40.9	32.0
270											49.4	7.0	50.1	21.8	42.9	18.5	40.0	30.2	36.8	44.3							39.5	32.0
275			36.7	39.5	39.9	30.2	42.1	14.7	44.3	10.8	48.6	7.8	47.0	12.4	39.0	32.0	36.9	40.6	36.0	47.0	36.0	49.8	36.0	48.5	36.2	49.5	38.6	39.5
280											48.4	8.6	43.7	18.5	37.9	32.0											37.6	42.5
285									44.6	10.8	46.4	8.5	42.0	20.0	36.7	39.5	36.3	37.8									37.2	44.3
290											46.4	11.9	40.9	21.0			35.7	50.7										
295									44.5		44.1	13.8	37.5	34.8	35.9	42.0											36.8	46.3
300	34.3	49.5	36.4	32.5	38.3	32.0	41.9	16.0		13.8		33.5	35.9	37.8	35.5	46.0	35.6	52.5	35.3	55.3	35.3	53.0	35.9	47.5	36.0	46.3	36.7	45.5
305							42.3	23.0	44.0	12.4	38.5	24.3																
310											36.8	35.0	35.6	43.0														
315							41.9	25.8	44.4	12.9	36.0	47.0																
320									42.8	16.8																		
325					39.2	33.5	41.0	22.5	41.2	15.8	34.7	42.8	35.3	49.8	35.0													
330							38.9	22.5	39.3	22.0																	36.0	47.5
335							39.1	28.4	36.3	37.8																		
340							37.6	29.8	35.6	41.0																		
345							36.0	37.8	34.8																			
350	34.5	47.8	36.2	36.5	38.5		35.1	44.3	34.8	47.5	34.7	49.8	33.9	49.8	34.9	48.5	35.1	53.0	35.0	55.3	35.5	49.8	35.5	50.7	35.3	50.7	35.9	48.0
355					38.6																							
360					38.1																							
370					37.4	34.0																						
375			36.3	37.8	36.2	38.5			34.9	42.8																		
380					35.5	42.8																						
385					35.1	45.5																						
390					34.9	42.0																						
400	34.4	44.3	35.7	44.3	34.4	46.0	34.8	46.3	34.2	48.0	34.3	50.7	33.8	50.7	34.5	49.5	34.7	50.7	34.9	53.0	34.9	51.5	35.1	51.4	34.9	50.2	35.1	49.0
450			34.9	39.5																								

Table 3. Brand "A"—Final Annealing Data.

BRAND "B" - OFHC COPPER

Tensile Strength (ts, in thousands of psi) and Uniform Elongation (e, in percent) in Relation to Cold-Work and Annealing Temperature

Degree of Cold-Work (%)	0.0		4.8		11.4		15.3		20.8		27.9		37.0		48.5		60.1		68.3		74.7		84.8		90.0		93.4	
Annealing Temperature (C)	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e
20 (Room)	34.6	48.5	36.1	37.5	38.9	27.5	42.4	8.0	44.5	2.5	50.3	3.0	50.9	3.0	53.3	2.5	57.5	2.5	58.6	2.5	60.6	2.5	60.5	3.0	61.6	2.5	63.1	4.0
100	34.1	48.5	35.8	41.5	39.2	26.2	42.5	8.0	44.8	2.4	49.8	3.0	51.4	3.0	53.5	2.5	57.0	2.5	58.1	2.5	60.7	2.5	60.6	2.4	61.6	2.5	63.0	4.0
150	34.3	49.8	35.8	35.0	39.0	26.7	43.2	8.0	45.4	2.4	50.1	3.0	51.2	3.0	54.0	2.5	56.9	2.5	58.4	2.5	60.6	2.5	60.4	2.5	60.8	2.5	62.1	4.4
175	34.6	42.0	35.7	37.8	39.1	19.8	42.7	7.7	45.6	2.5	49.8	3.0	51.0	3.5	53.8	2.5	56.8	2.5	58.3	2.5	60.6	2.5	60.2	2.5	61.0	3.0	61.7	5.0
200	34.4	46.0	35.9	37.5	39.0	26.7	42.8	6.5	45.2	3.8	49.6	4.0	51.0	3.5	53.3	3.5	56.2	3.0	58.1	2.5	59.5	2.5	59.8	2.5	60.2	2.5	61.0	4.0
210																										8.0		
215																											60.2	5.0
220																										12.4		
225																	56.3	2.5	57.7	2.4	59.0	3.3	58.3	3.5	56.1	6.5	58.9	5.0
230																									55.6	7.8		
235																									52.2	7.8	57.8	5.8
240																					53.6	2.5	54.8	8.0	50.0	10.8	55.6	8.6
245																									48.3	5.8		
250	34.5	46.0	35.6	44.5	39.0	26.2	42.4	10.5	45.2	5.0	49.3	2.5		2.5	52.4	2.5	55.0	3.5	57.0	2.5	58.8	2.5		6.0		8.6	53.4	10.8
255																					54.1	7.0	49.2	19.8	46.1	26.2		
260																	56.3	4.3	56.4	3.8	53.2	6.8	44.4	27.5	41.6	17.5	48.3	15.8
265																					51.3	11.5	42.6	29.8				
270																	54.7	3.0	51.7	6.8	48.2	13.4			40.5	33.0	45.4	19.5
275			35.6	42.0							49.7	3.8	51.3	2.5	53.4	2.5	54.2	3.0	49.9	12.4	46.4	19.8	39.7	36.0		30.2	42.5	27.0
280																					48.8	26.0	39.5	39.5				
285																	48.6	15.8	48.7	16.8	48.0	28.4	39.4	37.8	37.8	39.5	39.8	35.0
290													50.8	4.0	51.3	5.0	48.9	11.8			48.2	34.8	37.9	44.3				
295																	46.5	16.8	48.8	19.8	48.1	33.8	37.2	44.3	36.8	46.0		
300	34.5	46.0	35.8	37.5	38.8	21.8	42.1	7.5	44.7	11.5	49.2	5.0	50.1	4.4	48.9	8.6	46.0	16.0	48.9	36.8	38.8	46.0	37.1	48.5	36.6	42.8	37.1	46.0
305																		11.1										
310													49.7	4.0			42.1	29.0	38.4	42.0	36.9	42.0	36.3	44.3	36.1	48.5		
315									44.8	10.5							39.8	32.0										
320											48.5	4.0	46.9	9.5	46.6	14.0	39.1	36.0										
325							42.5	11.1	44.1	10.8			44.0	15.0			36.5	48.5	36.2	50.7	36.2	49.8	35.9	51.5			36.2	50.2
330															43.2	23.0												
335											46.8	11.1	45.5	11.7	40.1	30.2	36.2	50.7										
340							41.7	20.0	43.9	19.5																		
345							41.8	12.4			46.1	13.8	40.8	22.5	38.0	30.2												
350	34.4	47.5	35.5	38.5	38.8	25.0	41.0	10.5	42.7	13.8	44.0	16.8	39.6	25.0	37.1	34.0	35.0	53.0	35.0	47.8	36.0	48.5	35.9	49.0	35.9	49.8	35.7	50.2
360					38.6	23.0	40.7	15.0	42.8	10.8	41.9	16.3	37.2	34.8	35.2	36.4												
365							41.1	19.5	42.5	20.8																		
370					39.1	30.2	39.8	29.0																				
375					38.7	30.2	39.2	24.6	41.3	21.8	35.6	42.8	34.8	49.5	34.7	47.0												
380					37.9	23.3																						
385							39.3	25.0	39.2	26.0																		
390							38.7	28.0	38.6	26.2	34.2	47.0	34.3	50.7	34.5	52.0												
395									36.7	38.3																		
400	34.3	46.3	35.9	39.5	37.6	23.3	38.0	30.2	35.0	46.3	34.0	48.5	33.7	49.5	34.6	48.5	34.3	50.5	35.0	50.7	35.6	49.9	35.7	49.5	35.4	47.5	35.2	50.2
405							35.9	34.0																				
410							35.8	29.0	34.2	46.3																		
415							35.2	39.5																				
425							34.0	33.0	33.9	47.5	33.8	50.7	34.1	52.5	34.1	53.0												

Table 4. Brand "B"—Final Annealing Data.

BRAND "C" - TOUGH PITCH COPPER

Tensile Strength (ts, in thousands of psi) and Uniform Elongation (e, in percent) in Relation to Cold-Work and Annealing Temperature

Annealing Temperature (C)	Degree of Cold-Work (%)																											
	0.0		4.8		11.4		15.3		20.8		27.9		37.0		48.5		60.1		68.3		74.7		84.8		90.0		93.4	
	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a
425																												
420																												
415																												
410																												
405																												
400																												
395																												
390																												
385																												
380																												
375																												
370																												
365																												
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320																												
315																												
310																												
305																												
300																												
295																												
290																												
285																												
280																												
275																												
270																												
265																												
260																												
255																												
250																												
245																												
240																												
235																												
230																												
225																												
220																												
215																												
210																												
205																												
200																												
195																												
190																												
185																												
180																												
175																												
170																												
165																												
160																												
150																												
100																												
20 (Room)																												

Table 4. Brand "B"—Final Annealing Data.

BRAND "C" - TOUGH PITCH COPPER

Tensile Strength (ts, in thousands of psi) and Uniform Elongation (a, in percent) in Relation to Cold-Work and Annealing Temperature

Annealing Temperature (C)	Degree of Cold-Work (%)																											
	0.0		4.8		11.4		15.3		20.8		27.9		37.0		48.5		60.1		68.3		74.7		84.8		90.0		93.4	
	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a
425			34.4	39.5																								
415			34.4	37.8																								
400	33.5	48.5	34.6	42.0	33.8	48.5	34.2	48.5	34.5	49.8	34.2	47.0	34.0	51.5	34.3	53.5	34.5	53.0	34.5	50.2	34.9	50.7	34.9	56.5	34.8	53.0	35.0	51.5
390			34.8	38.8																								
375			34.8	37.5	34.6	43.0																						
360			35.0	39.5																								
350	33.7	47.5	35.3	38.5	34.2	46.3	34.7	47.5	34.6	49.5	34.4	48.5	34.1	50.7	34.3	53.0	34.8	53.4	34.7	53.0	35.2	51.5	35.5	52.0	35.5	49.8	35.3	50.7
340					34.2	37.8	34.3	48.0																				
330					34.2	47.0																						
325					34.7	36.0	34.4	46.0																				
320					35.9	33.0																						
315					36.0	27.8	35.0																					
310					38.5	27.5	35.6	38.5																				
305							36.4	35.0																				
300	33.5	47.8	35.4	42.0	38.3	28.8	36.8	28.4	34.8	48.5	35.0	48.5	34.8	50.2	34.6	52.5	34.9	53.0	34.9	51.5	35.3	49.8	35.6	54.8	35.8	48.5	35.7	49.8
295							39.7																					
290							40.1	21.5	36.1	37.5	34.4	53.0																
285									38.2	29.5																		
280							40.0	21.8	40.9	21.8	34.6	47.5																
275									41.5	18.5	34.9	49.5	34.4	50.7	34.7	51.5	35.0	54.5										
270							40.0	24.0	43.6	11.5	35.4	46.3	34.5	50.2														
265											36.9	32.0																
260							40.1	23.3	44.0	14.5	38.4	28.0	35.9	39.5	34.9	51.5	35.1	51.5										
255											45.0	15.0	37.7	37.5														
250	33.6	47.8	35.4	42.0	38.3	28.8	40.2	21.5	44.1	13.0	45.5	7.6	41.0	24.0	35.6	48.5	35.7	48.5	35.9	50.2	35.9	49.8	36.3	55.3	36.4	48.5	36.7	46.0
245											46.6	10.0	43.7	14.7	36.3	44.3	36.0	51.5										
240									44.4	16.8	48.1	8.0	48.8	9.0	37.6	34.8	35.9	46.3	35.8	50.7							37.0	42.0
235													48.5	8.0	41.8	20.8	37.2	46.3	36.7	44.0								
230													50.1	4.0	42.5	24.6	36.9	40.6	36.9	44.3	36.1	40.5						
225									44.2	9.0	48.6	8.0	50.1	4.0	49.3	6.2	40.6	33.0	38.9	44.3	37.3	32.0	36.4	44.3	36.3	46.3	38.8	36.0
220															51.0	6.5	42.4	25.8	40.0	29.5	37.6	34.0						
215															48.0	2.5	50.5	7.8	40.8	29.8	39.7	37.5	37.0	44.5	37.2	46.0	40.6	
210															52.2	3.3	53.7	4.4	47.4	8.6	44.0	19.5	38.8	37.8	37.3	39.5	43.5	23.8
205											48.8	6.0							49.0	11.1	46.7	19.5	43.0	30.2	41.0	31.0	46.8	17.5
200	33.6	46.0	35.6	39.5	38.3	25.0	40.2	20.0	45.0	13.4	48.8	4.0	50.8	2.5	53.1	2.5	54.6	4.5	53.0	4.4	49.0	8.6	44.4	20.0	41.4	30.2	50.3	9.5
195																			55.2	4.5	52.5	10.5	48.1	19.8	44.1	23.0	54.4	5.8
190																			56.0	3.5	56.1	5.0	50.4	24.0	46.0	18.0	56.5	4.5
185																					57.1	4.5	52.2	13.8	56.0		58.1	3.5
180																							57.1	8.0	54.9	5.0	59.2	3.3
175	33.7	47.8	35.7	37.5	38.8	21.8	40.2	24.3	45.1	5.0	49.0	4.0	50.8	2.5	53.2	5.5	55.6	2.5	56.1	3.5	57.9	3.3	58.8	3.5	57.5	5.0	60.6	3.8
170																							58.6	4.0	59.1	3.5	59.7	3.0
165																							59.8	3.3	60.4	2.5	60.8	2.5
160																									60.6	2.5		
150	33.7	46.0	35.4	42.8	38.9	26.7	40.1	21.0	45.0	5.0	48.8	2.5	50.1	2.5	53.2	3.0	56.3	2.5	56.1	3.3	56.7	3.3	59.7	4.0	60.7	4.4	61.6	3.3
100	34.0	46.0	35.6	39.0	39.0	25.0	40.1	19.5	44.4	4.4	49.2	2.5	51.1	2.5	53.2	3.0	56.3	2.5	56.7	3.3	57.3	3.3	60.6	3.3	60.5	3.3	62.2	4.0
20 (Room)	33.9	48.5	36.0	39.0	39.2	30.2	40.1	15.5	44.7	3.8	49.2	2.5	51.0	2.5	54.2	4.0	56.2	2.5	56.5	3.3	57.9	3.3	60.8	4.0	60.5	3.0	62.1	2.5

Table 5. Brand "C"—Final Annealing Data.

BRAND "D" - "TENSILOK" COPPER

Tensile Strength (ts, in thousands of psi) and Uniform Elongation (e, in percent) in Relation to Cold-Work and Annealing Temperature

Degree of Cold-Work (%)	0.0		4.8		11.4		15.3		20.8		27.9		37.0		48.5		60.1		68.3		74.7		84.8		90.0		93.4	
Annealing Temperature (C)	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e	ts	e
(Room) 20	36.1	43.5	37.9	31.8	39.0	25.0	45.1	11.7	46.6	4.4	50.9	3.3	52.5	3.5	55.4	3.3	58.1	4.3	59.7	2.4	60.6	2.5	62.4	2.4	63.4	2.0	64.9	4.0
100	36.4	42.0	36.1	34.0	39.4	25.8	43.3	12.6	46.6	4.0	50.3	2.5	52.3	3.8	55.0	4.0	58.1	2.5	60.4	2.0	60.8	2.4	62.6	2.4	63.2	3.3	63.8	3.8
150	36.6	42.0	37.7	34.0	40.0	25.0	43.5	12.6	46.4	4.0	50.3	2.5	52.1	3.3	55.0	2.5	57.7	2.4	59.8	2.5	60.0	2.4	62.8	2.4	63.4	3.3	64.0	3.8
175					39.6	25.0	42.9	12.4																				
200	36.8	42.5	37.7	35.5	39.8	25.5	44.1	12.9	46.2	4.4	50.5	3.3	52.5	3.8	54.8	3.6	58.1	3.5	59.1	2.0	59.7	2.5	62.2	2.5	62.8	3.3	63.2	3.8
210																							61.2	3.0				
225							43.1	12.9					51.9	3.5	55.2	4.3	57.3	3.0	58.9	2.5	60.0	2.4	60.2	4.0	61.8	3.5	62.4	3.8
240																	57.7	2.5	59.3	2.4	58.7	2.4	59.1	2.5				
250	36.4	42.5	37.7	34.0	39.6	24.3	43.5	14.5	46.2	7.5	50.1	5.5	52.1	4.5	55.2	3.5	57.1	3.8	58.5	3.0	59.1	2.5	59.1	4.5	61.2	3.5	61.0	5.0
260																	57.1	4.0	58.5	2.5	58.3	5.0	58.3	5.0				
265																			56.0	6.5	58.1	5.0	52.1	8.0				
275					39.4	25.8	42.7	16.3	45.7	9.3	49.5	6.0	51.3	5.0	54.4	5.0	56.2	3.0	56.9	6.2	57.3	4.4					60.0	4.3
285																					54.4	5.8						
290													51.1	6.2	54.0	3.8	55.0	4.5	56.0	4.4	54.5	5.8					55.8	6.2
295																							48.6	14.7	53.8	9.0	55.0	13.0
300	35.8	43.5	38.1	36.0	39.6	25.8	43.1	16.3	45.7	9.5	49.0	9.0	50.7	3.5	52.6	6.0	54.8	5.8	51.9	8.6	53.3	12.4	46.6	5.2	52.8	6.5	55.6	4.4
305																	52.1	8.0										
310									45.5	14.7					51.3	9.8	52.8	8.0			49.1	13.4	45.3	23.0	50.1	14.5	50.7	11.9
315											48.6	9.0	50.5	6.0	48.6	10.0												
320																	50.5	13.8	47.0	16.8							48.2	16.8
325			38.1	35.5	39.2	25.5	42.4	14.0	44.9	9.8	48.8	9.5	50.7	8.0	48.4	15.0					46.4	20.8	43.3	26.7	47.0	18.0	48.4	15.8
330																	45.1	18.5									49.1	15.5
335																							42.2	26.7	45.1	25.0		
340					38.7	29.8			44.7	16.8	47.6	9.0	47.2	9.8	43.1	21.8	41.0	28.0	43.1	31.8	42.7	25.0					44.3	22.0
345																			41.4	30.2	41.6	27.8					45.7	31.0
350	35.6	44.3	37.7	35.0	39.2	25.8	42.4	19.0	44.9	9.5	46.8	10.3	44.9	13.0	39.0	35.5	37.9	43.5	40.2	36.0	39.2	33.5	38.9	41.5	40.8	36.5	38.5	38.8
360			37.3	36.0			42.2	18.5	44.3	14.5	42.7	14.7	40.8	36.0	37.1	44.3	38.5	36.8	37.9	42.0	38.1	38.3	37.7	40.2				
365																											37.3	40.-
370											41.4	24.3																
375			36.9	37.8	35.0	27.5	41.6	19.0	43.1	17.0	39.4	28.8			35.8	45.0	36.3	49.0	36.9	46.3	36.7	43.0	37.3	43.0	38.1	42.5	37.1	38.5
380											37.3	39.0	36.9	44.3														
390			37.1	33.8	36.0	27.8	41.6	20.8	40.6	26.0	36.1	46.3	37.5	47.5	35.6	47.0							36.1	42.0				
400	35.9	44.3	37.5	35.5	39.0	32.5	40.8	25.0	39.2	38.5			36.3	46.3	36.1	48.0	36.1	48.5	36.9	46.3	36.9	45.5	35.4	43.5	36.7	45.0	36.5	41.5
410					37.9	29.5	38.9	29.0	35.9	43.5	35.2	47.5	35.6	45.0							36.1	47.8	35.9	45.5				
425			36.9	37.8	37.9	34.0	35.9	36.8	35.4	44.3	35.4	48.5	35.6	48.0	35.2	48.0	35.4	48.0			35.9	48.5	35.9	46.3				
440					37.1	32.0																						
450			36.5	36.0			35.4	45.0	35.2	47.0	35.2	48.0	35.6	47.8	35.2	48.5	35.0	49.8	35.6	48.0	35.8	48.5	35.8	46.3	35.8	46.0	35.9	47.5
460					36.1	38.5																						
465			36.5	35.0	35.8	42.0	35.4	46.3	35.0	44.5	34.8	46.6	35.2	47.5														
475							35.0	44.3											35.6	48.0								
485			36.3	36.0	35.2	44.5																						
500	35.6	44.3			35.8	45.0	36.5	45.0			35.4	49.0	35.6	48.0	34.8	48.0	35.2	48.5	36.3	48.5	36.3	48.5	35.8	47.8	35.9	47.5	36.4	46.0
510																					35.2	48.5	35.0	48.0				
525			35.9	42.5	35.2	44.3	35.2	44.3	34.8	46.3									35.2	49.8								
550			35.4	41.5	34.4	44.5	35.4	44.3	35.0	45.5	35.0	47.0	35.0	47.5	34.8	48.5	34.6	49.0	34.8	49.0	34.8	48.5	35.2	47.8	35.0	48.0		

Table 6. Brand "D"—Final Annealing Data. * * * * * * *

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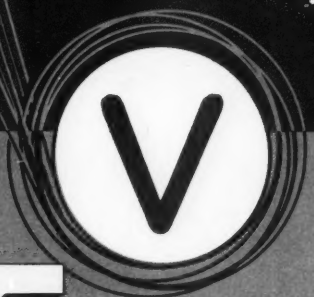

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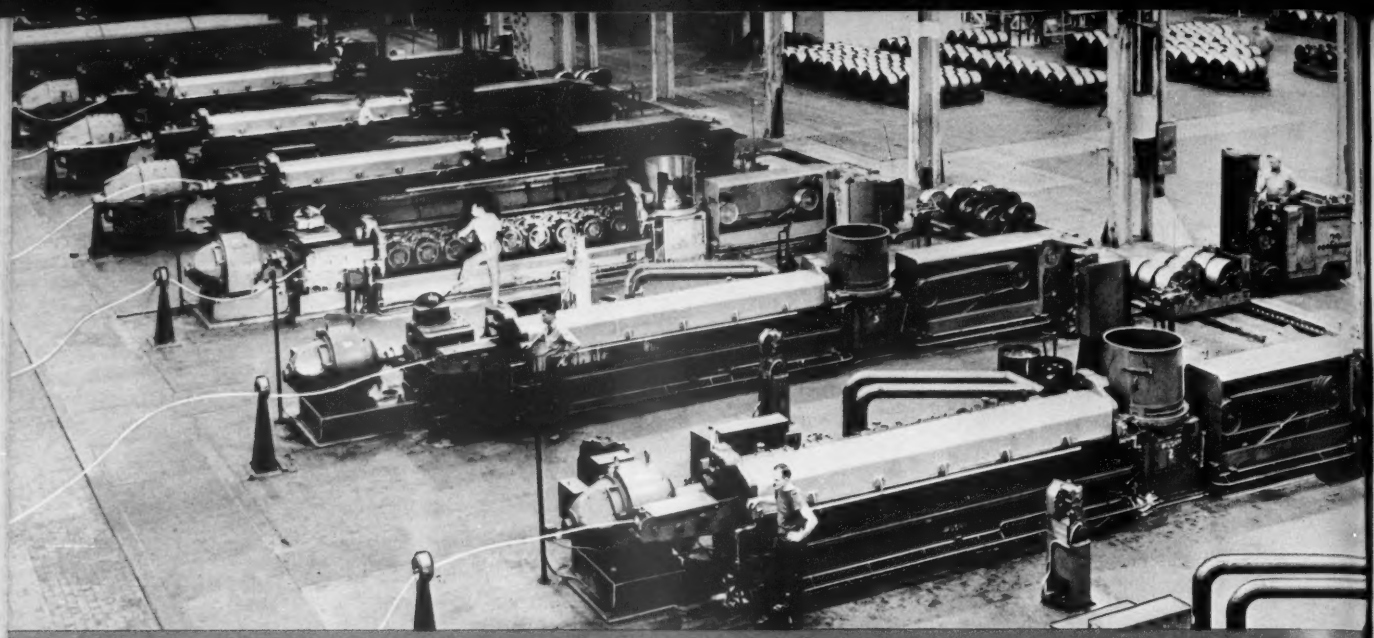

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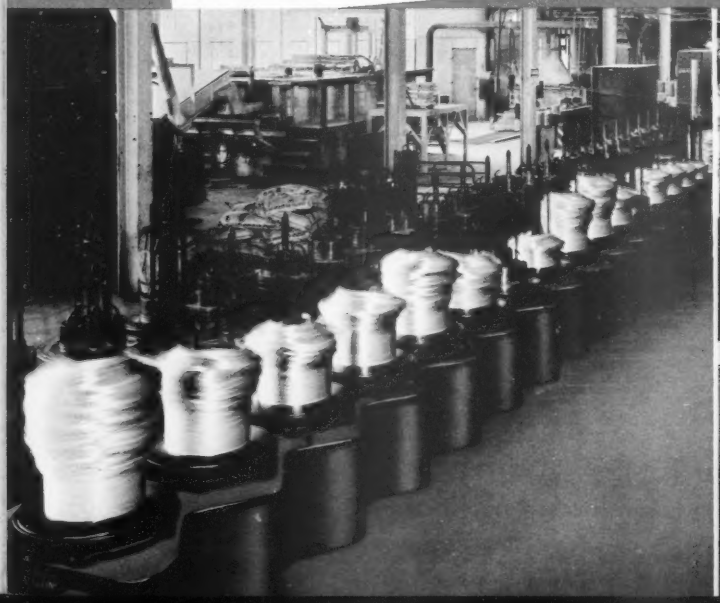

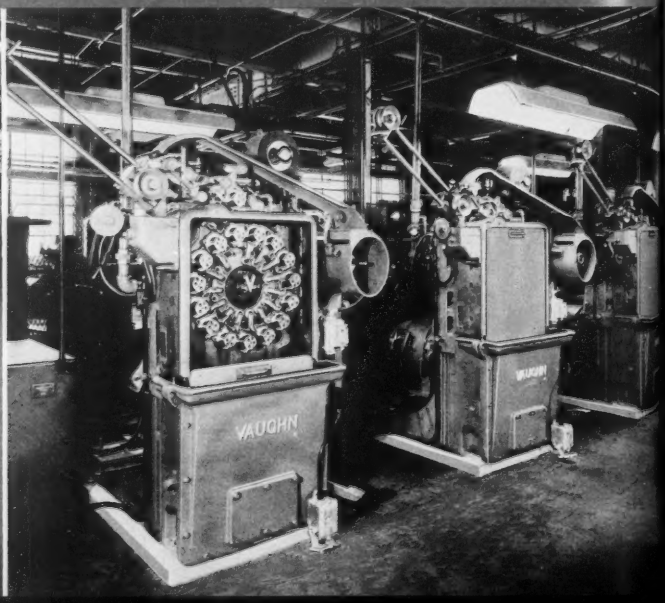

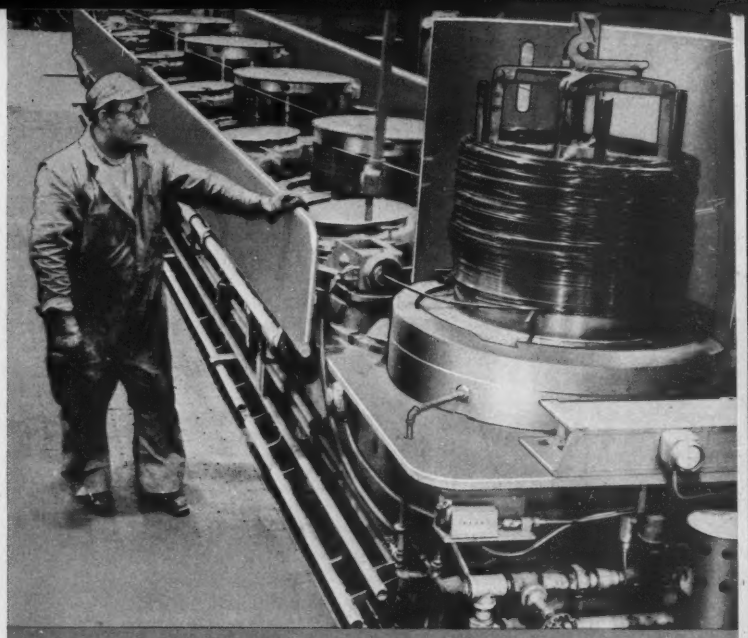

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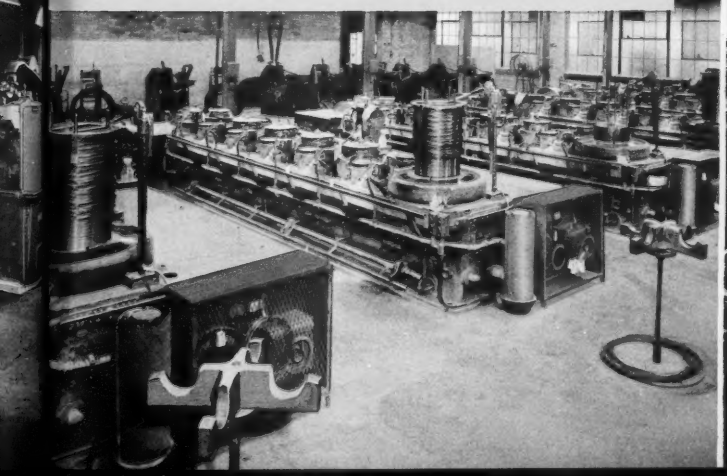

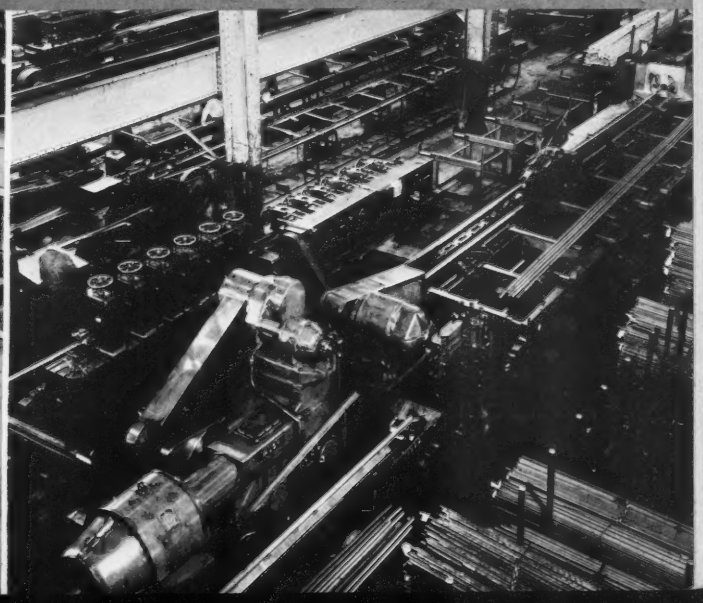

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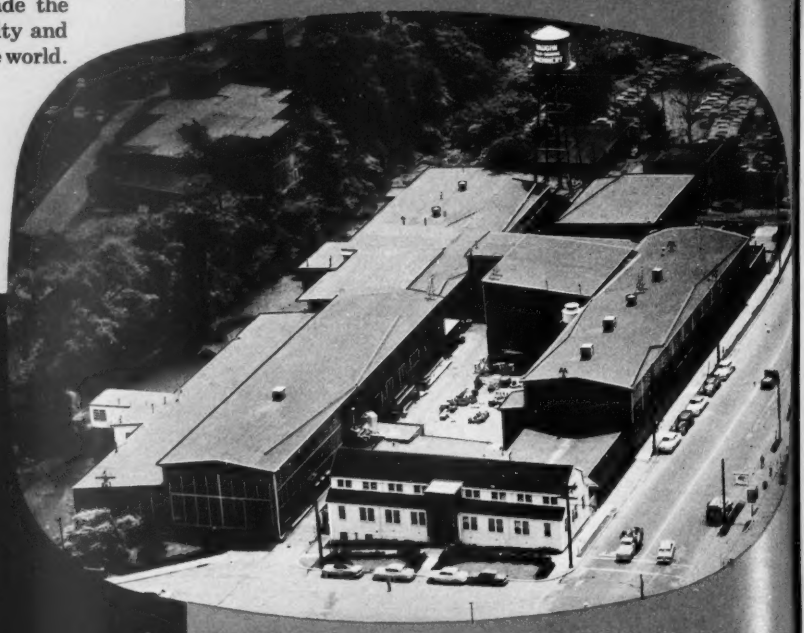

THE Vaughn MACHINERY COMPANY

CUYAHOGA FALLS, OHIO, U.S.A.

BRAND "P" - HIGH PURITY COPPER

Tensile Strength (ts, in thousands of psi) and Uniform Elongation (a, in percent) in Relation to Cold-Work and Annealing Temperature

Degree of Cold-Work (%)	0.0		20.8		37.0		50.0		75.0		87.5		93.4	
Annealing Temperature (C)	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a	ts	a
(Room)	20	34.4 45.0	44.7	8.5	53.0	3.5	56.5	3.3	60.6	4.3	62.8	3.8	63.6	3.5
	100	34.4 46.3	45.9	9.0	53.0	2.5	56.0	4.3	60.6	3.3	63.0	3.0	63.4	4.0
	115		45.5	5.8							61.8	3.8		
	120										61.0	4.5	63.0	4.3
	130										61.8	3.8		
	140										61.4	2.5	62.4	3.3
	145										62.6	2.5		
	150		45.5	9.8	53.2	2.5	56.2	3.5	60.4	4.0	61.4	3.3	62.0	3.3
	160	34.2 44.5							60.4	3.5	60.2	3.3	59.8	4.5
	170						55.8	3.5	59.5	4.3	56.9	5.0	51.5	5.8
	175		45.3	7.5	52.7		55.6	2.5	58.3	2.5	45.9	11.5	41.4	26.7
	180	34.4 47.8							56.3	3.0				
	185										43.5	25.0	38.3	33.8
	190	34.4 52.5			52.8	3.8	55.4	3.3	44.1	13.4	39.4	29.5		
	195								43.5	13.8			36.1	46.3
	200		45.1	10.0	52.5	4.4	48.6	5.0	36.1	45.0	36.1	43.5	35.6	49.8
	210		45.5	9.5	51.7	4.0	44.3	10.8	35.8	45.5				
	215						35.2	48.5					35.6	47.8
	220				43.3	12.4	35.9	37.8			35.6	48.5		
	225				35.6	38.8								
	230		44.9	9.0	36.3	29.5	34.8	47.5						
	240		43.3	13.0	34.4	42.5								
	245		39.8	11.7										
	250		36.7	23.8	34.4	43.0	34.4	53.5	35.4	48.5	35.6	47.0	35.4	49.0
	255		36.7	22.5										
	260	34.2 49.5	33.8	34.0										
	270		34.0	46.3										
	300	34.4 50.7	33.6	47.5	34.2	52.0	34.2	51.0	35.6	49.5	35.4	47.5	35.0	49.0
	350	34.2 54.0	33.6	47.0	34.0	51.0	34.2	52.0	34.8	49.5	35.4	50.2	35.0	49.5
	400	34.2 55.0	33.4	47.0	33.6	52.0	34.2	51.0	35.0	51.5	35.0	49.0	34.4	49.0

Table 7. Brand "P"—Final Annealing Data. * * * * * * *

Actually neither the tables nor the space diagrams reveal too well the effect which cold-working alone has upon the brands of copper tested. To reveal this effect clearly the so-called "work-hardening characteristics" are of service. Such characteristics have been assembled for each copper and are shown in Figure 15. As may be seen in this figure, each characteristic is composed of curves relating tensile strength (ts) and elongation (a), with the degree of cold-work in terms of percent reduction. The characteristics are supplemented by two additional curves T_1 and T_3 which denote the temperatures of the beginning and that of the end of the main change in the properties. The data for plotting these two curves are collected in Table 8 and have been obtained from reannealing characteristics by drawing tangents to

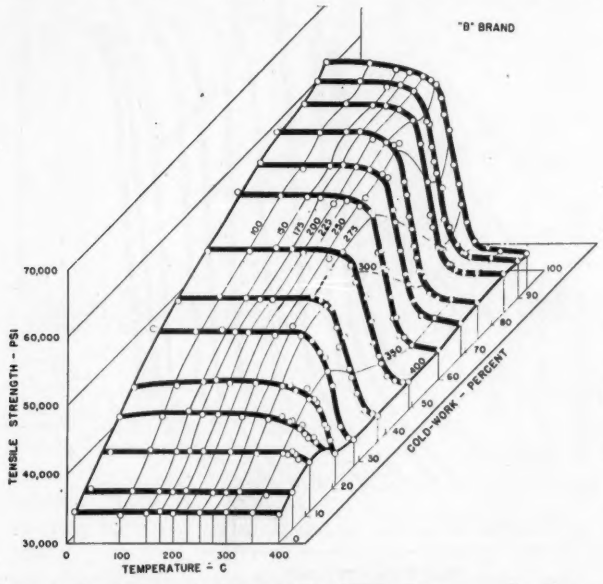

Figure 6. Tensile Strength of Brand "B" (OFHC) Copper as a Function of Percent Reduction and Temperature on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * * * * * * * * * *

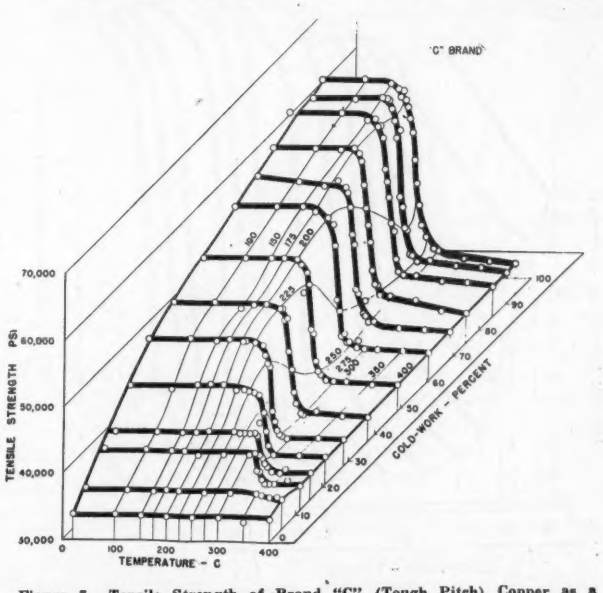

Figure 7. Tensile Strength of Brand "C" (Tough Pitch) Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * *

initial and the end portions of these curves and by noting the temperatures at which the tangents started to depart from them. In this manner the characteristics provide basis for quantitative assessment of:

a) the improvement in load carrying capacity due to cold-working (tensile strength curve), b) capacity for further deformation (elongation curve), c) thermal stability of the work-hardened structure (T_1 curve), and d) minimum full annealing temperature (T_8 curve).

Discussion of Results

The spectroscopically pure copper "P" represents pure elemental copper. The other brands, can and will be regarded as derivatives from this pure copper obtained either by incidental or factual alloying. In view of the above it is correct to treat the "P" copper as standard copper, and the results obtained with it, as standard results against which other results should be compared. Such an approach brings about an advantageous simplification of the discussion. Another simplification will be secured by focusing the discussion of results primarily on the findings pertaining to tensile strength. Such an approach is fully justified by the fact that both tensile strength and elongation are about equally sensitive to structure changes. A close inspection of Tables 2-5 and diagrams 5-15 will confirm the above statement.

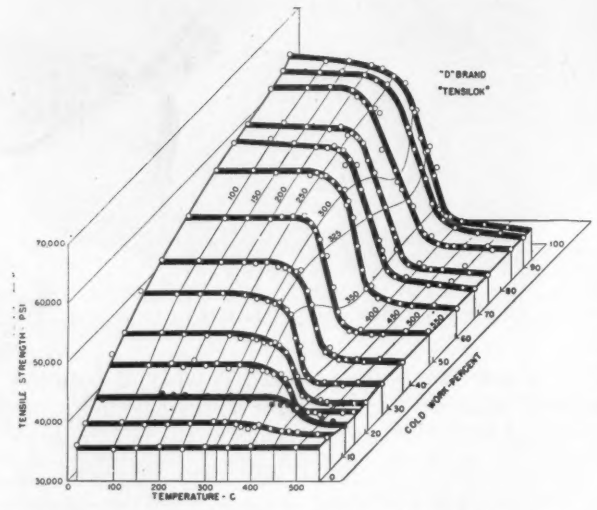

Figure 8. Tensile Strength of Brand "D" ("Tensilok") Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * *

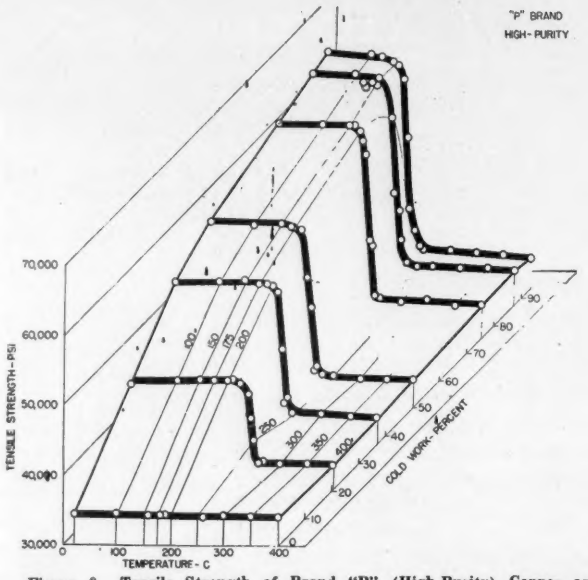

Figure 9. Tensile Strength of Brand "P" (High-Purity) Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * *

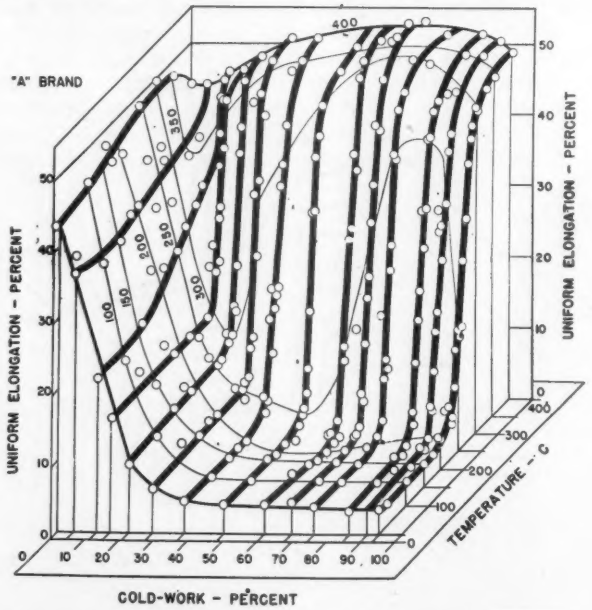

Figure 10. Uniform Elongation of Brand "A" (Tough Pitch) Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * *

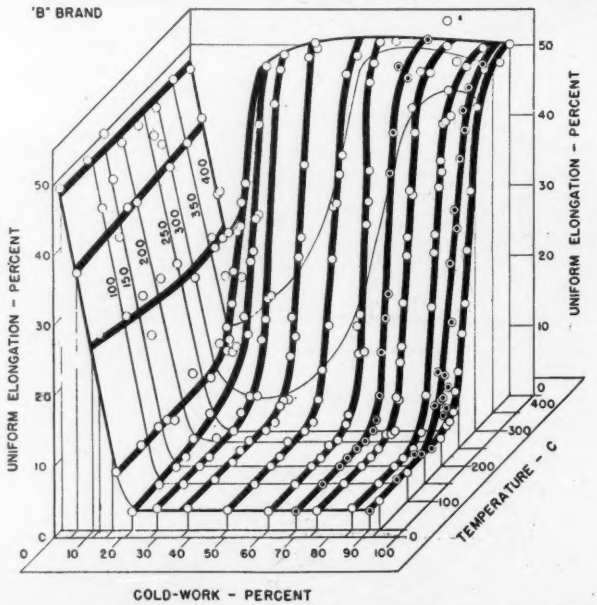

Figure 11. Uniform Elongation of Brand "B" (OFHC) Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * * *

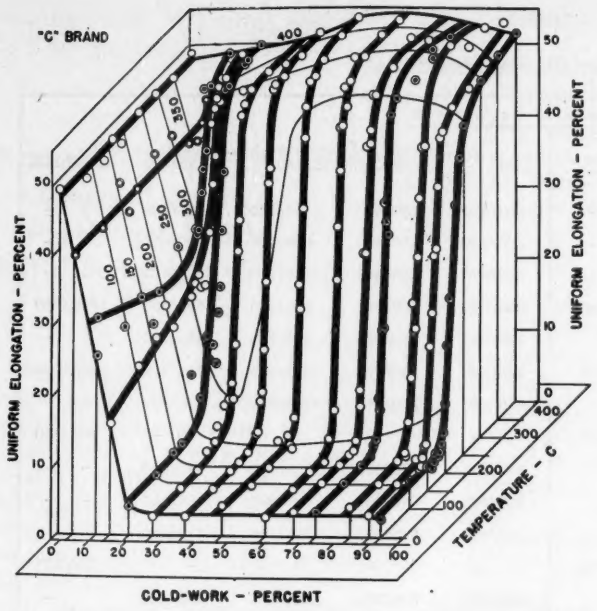

Figure 12. Uniform Elongation of Brand "C" (Tough Pitch) Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * *

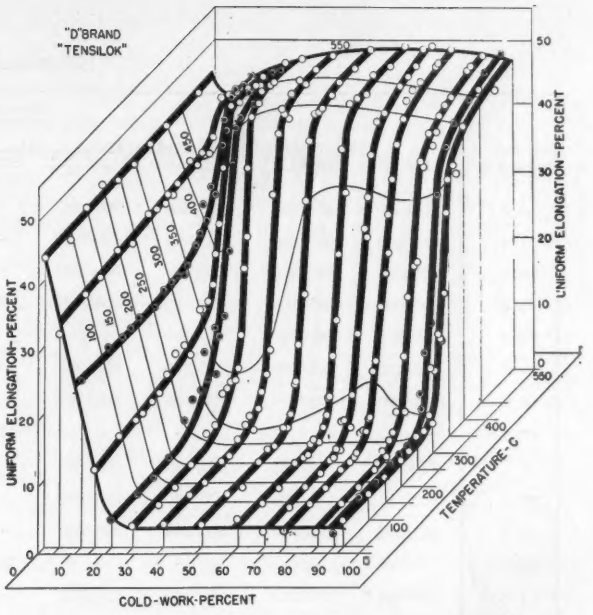

Figure 13. Uniform Elongation of Brand "D" ("Tensilok") Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * *

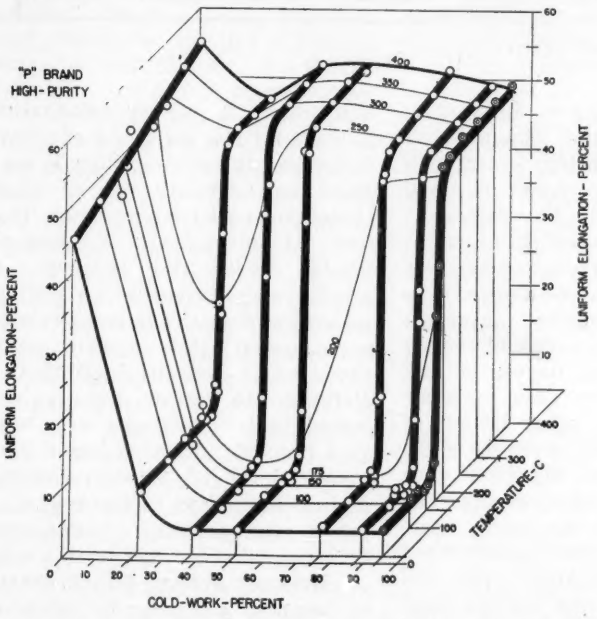

Figure 14. Uniform Elongation of Brand "P" (High Purity) Copper as a Function of Percent Reduction and Temperature of Exposure Reached on Progressive Reannealing. Heating Rate Employed—10.8 C/minute. * *

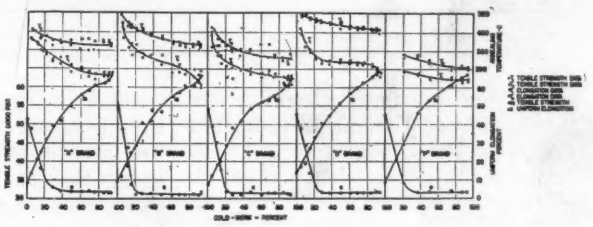

Figure 15. Work-Hardening and Reannealing Characteristics of Copper Brands Tested. * * * * * * * * * * * * * *

Accuracy

The proximity of experimental points to the curves drawn indicates the achievement of a satisfactory degree of overall experimental accuracy. The presence of many points in the region where the "progressive reannealing characteristics" have their main change permitted the charting of the curves to a degree hardly known in technical literature.

Annealing of Wires With Zero Percent Reduction

Reannealing of already fully annealed wires may appear to be pointless, yet it was carried out as a control measure. By doing it, it was possible to "round off" the series of degrees of cold-work and also, to obtain a check on the quality of the penultimate annealing, as well as of the general adequacy of precautions used in annealing and accuracy of testing.

★ ★ ★

The tensile strength of copper "P" with zero percent reduction and that of all other brands with zero reduction, is not affected by an additional progressive heating up to 400 C, and by water immersion which followed. This may easily be seen in Figures 5-9. Similarly, this is true of the elongation of coppers "B", "C", and "D" (Figs. 11-13) but not about the elongation of the copper "A" (Fig. 10) and the standard "P" copper (Fig. 14). The pure copper shows on annealing to 400 C a steady increase in elongation amounting to 10 percent, while copper "A" shows a somewhat less

TABLE 18

Softening Range of Copper Brands Tested

Percent Reduction	Temperatures in Centigrade of The beginning of softening — T_1					The end of softening — T_2				
	Brand "A"	Brand "B"	Brand "C"	Brand "D"	Brand "P"	Brand "A"	Brand "B"	Brand "C"	Brand "D"	Brand "P"
4.8	355/360*	425/370	325/385	390/425	— —	>400/410	500/450	425/>400	485/495	— —
11.4	345/340	355/330	295/275	340/325	— —	400/400	450/430	330/365	500/500	— —
15.3	305/300	340/275	280/235	300/290	— —	360/370	440/425	335/350	470/470	— —
20.8	275/285	335/300	220/160	250/270	200/190	350/370	425/405	305/325	470/450	270/280
27.9	240/255	290/260	210/150	240/230	— —	325/350	400/400	295/305	410/450	— —
37.0	260/230	275/275	200/200	230/250	175/175	350/350	390/385	275/315	440/450	270/270
48.5	185/220	225/275	175/205	235/250	— —	325/350	380/375	290/310	425/435	— —
50.0	— —	— —	— —	— —	150/155	— —	— —	— —	— —	265/250
60.1	210/195	185/225	160/180	230/250	— —	310/360	355/340	275/335	440/450	— —
68.3	160/185	185/225	175/190	225/235	— —	305/360	350/325	275/335	425/420	— —
74.7	145/175	175/200	165/175	225/235	— —	305/355	325/325	265/285	445/430	— —
75.0	— —	— —	— —	— —	150/165	— —	— —	— —	— —	200/215
84.8	155/185	160/200	125/160	215/225	— —	360/350	325/340	250/260	425/425	—
87.5	— —	— —	— —	— —	140/145	— —	— —	— —	— —	220/220
90.0	160/180	125/170	150/165	200/210	— —	350/340	305/360	245/230	410/420	— —
93.4	160/180	100/195	120/165	160/250	140/145	325/325	320/350	260/285	400/400	210/210

*The figures at the left have been derived from the tensile strength curves.
The figures at the right have been derived from the elongation curves.

steady and smaller increase. Such a behavior of elongation indicates the penultimate annealing of these two coppers did not leave them in a fully stabilized condition and that some minor structure changes, presumably a continuation of crystal growth, did take place on additional exposures. The absence of similar changes in brands "B", "C", and "D" can be accounted for by some cumulative action of their impurities which apparently inhibit the tendency to increase the crystal size. The fact that elongation responded to the above considered changes and the tensile strength did not, implies that elongation is somewhat more sensitive to microstructure changes.

Progressive Cold-working

The behavior of the standard, as well as other coppers tested on cold-plastic deformation, can best be studied by means of work-hardening characteristics shown in Fig. 15. The tensile strength curve for the "P" copper forms familiar, progressive work-hardening characteristics and supplies information about the load carrying capacity of this copper when deformed by drawing to any reduction between 0 and 93.4 percent. The rate of gain in tensile strength is greater in the region of small reductions than in the region of medium and high reductions; after about 30 percent reduction the rate of gain being more steady. The load carrying capacity, as measured by tensile strength, obviously improves with the degree of cold plastic deformation. Save for some minor differences, other brands of copper have tensile strength characteristics almost identical with those of the standard brand. The progressive work-hardening characteristics of coppers tested, based on uniform elongation, are also near identical except for the position of the point where the initial steeply decreasing part of the characteristics merges with the level part. Brands "P" and "A" have this point near 30 percent reduction while other brands show it in the vicinity of 20 percent.

Effect of Low Temperature Exposures on Slightly Work-Hardened Wires

Metals with low reductions (i. e.,) with reductions lower than the one at which elongation reaches its low level) on exposure to temperatures lower than T_1 may show an unsteady run of their structure sensitive properties. This lack of steadiness, if present, would reflect the presence of strain—age-hardening. This effect would increase the indexes related to cohesion (ts) and/or lower those which describe ductility (a). Reference to Figures 9 and 14 will reveal that "P" copper wire with 20.8 percent reduction has a very steady level of tensile strength and of elongation in the region of lower temperature exposures. Strain-age-hardening in this case is obviously absent. Other brands of copper, as may be seen in Figures 5-8, also show a level run of tensile strength. The elongation of these coppers, however, does reveal a slight lowering of ductility and large scatter of experimental points in quite a number of instances (Figures 10-13). These brands, therefore, are subject to some slight strain-age-hardening effects that are commonly linked with presence of precipitation phenomena. It will again be noted that elongation data so simply derived are more useful for

showing fine structure changes than are the tensile strength data.

Reannealing of Wires With Low Degree of Cold-Work at Temperatures Which Cause Partial Softening (i.e., Between T_1 and T_3)

Pure copper "P" with 20.8 percent reduction starts to soften on heating at a temperature T_1 which is about 200 C, and is fully softened at T_3 = 270 C. As may be seen in Figures 9 and 14, the temperature at which the softening reaches a halfway (T_2) is just below 250 C. The commercial brands with the same percent reduction have their softening region of temperatures much higher. They are, therefore, of a higher thermal stability. Brand "D" at 20.8 percent reduction has its softening range between 250 and 450 C; the halfway softening temperature (T_2) is about 315 C. Elongation changes in wires with a lower percent reduction than 20.8 percent, made of brands "A", "B", "C", and "D" reveal in the region of temperatures under discussion a considerable scatter of experimental points. The lower the percent reduction the more pronounced this is. As a consequence of the scatter the course of the elongation curves in this region is not too accurately determined. Such curves, therefore, are less suitable for quantitative comparisons than are the curves of tensile strength. At least two reasons for the presence of scatter may be listed. The first is the high sensitivity of elongation to some fine changes in structure, most likely due to precipitation and grain growth phenomena, and the second is the influence of the surface roughness ("orange peel"), on accuracy of measuring the diameter of wires after fracture ("d"), which in turn, decides the numerical data of elongation. In view of the foregoing, any detailed comparisons between the various wires in this region, should rather be made on the basis of the tensile strength data and curves.

Exposure of Wires With Low Degree of Cold Work to Temperatures Higher Than T_3

The pure copper wire with 20.8 percent reduction after heating above the temperature of 275 C shows a fully level run of both tensile strength and elongation.

* * *

The fully soft structure imparted to it by primary recrystallization is apparently quite stable and not subject to crystal growth effects. The level of tensile strength here is substantially equal to that of the starting material and to the level produced on wires with high reductions by similar exposure to elevated temperatures.

* * *

The corresponding elongations, however, although quasi-equal to that of the starting material are not optimally high as may be seen in Figure 14. Save for minor numerical differences, corresponding wires made of other brands of copper show an identical behavior. The same can be said about wires with a lower than 20.8 percent reduction in the instances where the maximum temperature of exposure reached and exceeded the T_3. As may be seen in the diagrams, this did not happen in studying wires "A", "B", and "C" with very low reductions, their temperature T_3, being higher than 400 C limit used.

Exposure of Wires With Medium and High Reductions to Temperatures Lower Than T_1

As may be seen in Figures 9 and 14, such an exposure of the wires made of pure copper has no effect on the level of the properties studied. This indicates that copper more heavily cold-worked than 20.8 percent reduction is not subject to strain-age-hardening. The same is true for all other brands.

Exposure of Wires With Medium and High Reductions to Temperatures Higher Than T_1 and Lower Than T_3

In the pure copper "P" such an exposure produces the main drop in tensile strength and the main increase in the elongation as may be seen in Figures 9 and 14. These changes are well charted by experimental points and are very regular. The position of the temperature range in which these changes occur is not the same for wires with different reduction. A very similar behavior of all other brands of copper can be noted in Figures 5-8 and 10-13. A closer scrutiny of these diagrams in the region under consideration, which may be aptly described as the "recrystallization ravine", reveals a feature that to the best knowledge of the authors, has not been observed before. This consists of a distinct retardation of the softening process in heavily cold-drawn wires; i.e. with reduction larger than 85 percent. These wires, in accordance with many previous findings on copper and on other metals, are indeed of lower thermal stability than wires with medium or low reductions because they start to soften at lower temperatures. Their rate of softening however is more sluggish as revealed by a lesser steepness of the "ravine" and by the leveling of the isotherms. The apparent absence of this new feature in very pure copper "P" yields a clue that this behavior is somehow linked with the impurity content. Because of the above observation, as well as some other distinctive features, the newly observed phenomenon should not be directly linked with the one observed by Wood ([4]). It appears that a new feature of work-hardened metals has been uncovered, the fundamentals of which are as yet totally obscure, and in want of clarification.

Reannealing of Medium and Heavily Cold-Drawn Wires at Temperatures Above T_3

Standard copper and also all the other brands on exposure to temperature higher than T_3 produce, within small experimental error, a steady behavior of tensile strength. This is also the case with the elongation of high purity copper. The elongation of the other brands of copper as may be seen in Figures 10-13 tends to increase

with temperature. All these symptoms jointly indicate that the growth of crystals which undoubtedly took place on these exposures was not very pronounced, otherwise it would have been reflected more distinctly by the indexes used. The level of tensile strength obtained on these annealings is on the whole identical with that of the starting material. In coppers "P", "A", "B", and "C" a small increase of the tensile strength with the increased reduction may be noted. Copper "D" shows this effect to even a lesser degree. On the basis of generally known facts this should be attributed to the smaller size of crystals which the heavier reductions tend to produce. With the exception of copper "B", all other brands tested show a characteristic hump in elongation obtained on exposure to temperatures higher than T_3. As already pointed out, low reductions yield fully annealed wires with a low elongation. Reductions between about 30 and 75 percent induced in every brand of copper maximum ductility, often exceeding the elongation of the starting material. Reductions higher than 75 percent as a rule produced fully annealed material with a lower elongation.

Appraisal of Results From Designer's Point of View

Copper "P", because of its scarcity and high cost is of no practical interest. The other brands investigated, however, represent commercial grades of technically pure copper with high electrical and thermal conductivities. These brands, as well as many others, are on the market in a variety of standardized sections and "tempers". At some additional expense, they may be cold drawn or rolled to almost any desired cross-section and hardness. Standard and specially formed copper is used in large quantities in construction of electrical and heating equipment. Wherever possible, fully soft copper is avoided in applications where the copper part must sustain a load, because the employment of work-hardened copper in such cases leads to considerable economy of scarce copper and to a lower price of the equipment. A designer using work-hardened copper is interested in its load carrying capacity and in the temperatures up to which such a copper retains this valuable property.

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Much of the basic information concerning the coppers tested in which designers are interested is contained in Figure 15. They may find that all the brands at zero percent reduction (i. e. in fully soft condition) are, for all practical purposes, equally strong and equally ductile. This information will be amplified by recalling that it is possible to process these brands so that they will possess better ductility than that associated with 45 percent elongation. This feature is of interest to designers who are facing extremely heavy cold forming of parts. Designers will find in Figure 15 that all the brands tested respond to cold-drawing almost identically. As it is known that work-hardening characteristics from drawing and rolling do not differ much; it follows that any brand, whether drawn or rolled to a given reduction, is as good as another for room temperature load carrying purposes. A reference to their limits of thermal stability of work-hardened structure, which is of course given by curves T_1 and T_3, show immediately that the brands differ considerably in that respect. Aside from brand "P", the brand "C" is least stable thermally while brand "D" is the most stable. Brand "B" apparently is much more stable than is brand "A". The relative order of stability of brands indicated above is present on every level of cold-reduction.

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Designers working in a specific field, will probably need some other pertinent information in addition to the minimum contained in the progressive work-hardening characteristics shown in Figure 15. When required, a suitable supplementation of Figure 15 should present no difficulty.

Survey of Results Obtained From The Point of View of a Process Metallurgist

The fabricator is vitally interested in both the work-hardening and the reannealing parts of the cycle that has been studied here.

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The results obtained under the conditions employed confirm the known fact that cold-working of high conductivity brands of copper results in substantially identical change in their mechanical properties. The minor differences encountered in these properties are obviously of no practical significance.

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In modern continuous annealing furnaces the heating cycle employed is basically the same as the one adopted for this investigation. Therefore, the results which pertain to reannealing are of direct industrial application to practice irrespective of whether the annealing operation is intermediate or final. The minimum temperature required for accomplishing full annealing under progressive heating conditions is, of course, readily provided by T_3 values. Table 8 and Figure 15 show this threshold temperature for every brand and temper tested.

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The foregoing information is also of value in the production of enameled magnet wire in which a varnish film is baked on it. As simultaneous full softening of the copper on such baking is preferred, obviously it can only be accomplished if the wire has its T_3 temperature lower than the enameling temperature.

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Pre-selection of lots of copper wire suitable for successful bake-annealing in the enamel department can readily be made by means of the progressive reannealing technique described herein. The small testing cost more than pays for itself by insuring a consistently soft product and absence of rejects due to "springy" wire. Copper lots which on testing reveal T_3 temperature higher than the enameling temperature employed are channeled to uses wherein ease of annealing is not a prerequisite.

(*Please turn to page* 1285)

The Treatment of Copper Conductors In High Velocity Recirculating Type Gas-Fired Ovens

by C. A. Windsor
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Baked enamel films on copper wires for electrical insulating purposes were introduced in this country about 1900 and were followed by similar developments in Germany shortly thereafter. The early enameling ovens were vertical counterparts of general purpose industrial ovens then coming into extensive use. A brief summary of the development of these general purpose industrial ovens will serve to highlight some of the material presented later.

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The early general purpose industrial oven had four walls and a roof with a hole in the top for ventilation. Fresh air leaked in around the doors and the bottom of the oven. Heaters were located on the two sidewalls near the floor. Neither recirculation nor the purpose of ventilation were understood in the era 1910 to 1915 and as a result these ovens had two common faults. Explosions and fires were quite frequent and the charge was over-heated on the sides and upper portion of the oven. The first improvement was made in ventilation. The primary reason for this was the loss of life and property caused by explosions and this attracted the attention of the insurance companies, who were paying the claims. The insurance laboratories studied the properties of paint and enamel solvents and thinners and by 1927 had developed a safe ventilation formula for finish bake ovens. The results of exhaustive laboratory tests on commercial solvents are published today in pamphlet form by the Associated Factory Mutual Insurance Company, Factory Insurance Association and the National Board of Fire Underwriters.

C. A. Windsor

The author graduated from the University of Michigan in 1930 with a B.S. degree. He has since been employed by General Electric Company, Bendix Aviation Corporation, Belden Manufacturing Company and Western Electric Company in the field of industrial heating, wire processing and allied fields. His present affiliation with Michigan Oven Company dates from September, 1953.

This paper was prepared for delivery before The Wire Association at its Annual Convention in Chicago, November 14-17, 1955.

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The general accepted rule for continuous process type ovens with solvent entering the oven and generating explosive gases at a slow, continuous rate, such as an enameling oven, demanded that the ventilation be 200 SCFM of air per gallon of solvent per hour. This is equivalent of the addition of approximately 12 BTU's per cubic foot of air introduced into the oven. The addition of approximately 100 BTU per standard cubic foot of air produces a mixture capable of complete combustion. That is, all of the oxygen in the air combines with all of the hydrocarbons in the solvent and the mixture is violently explosive. Mixtures containing less than 50 BTU per cubic foot will not generally support combustion at room temperature and this value is an approximation of what the insurance companies refer to as the Lower Explosive Limit or L.E.L. Thus we see the adopted rule for continuous process ovens insures oven atmospheres maintained at 25% of the L.E.L.

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The next improvement in oven design, one which has been very slow in development and which has not yet reached perfection, is the application of the recirculation principle to promote better temperature uniformity.

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In its early stages, prior to 1925, a separate fan was installed to take the hot air from the top of the oven and re-introduce it at the bottom of the oven, this being the coldest area. The capacity of the fan was determined by a rule of thumb, to turn over the air in the oven, two to five times a minute. Too often the size of the fan was influenced by the ability of the customer to pay. Nevertheless, temperature distribution was improved just about in proportion to fan capacity. From the period 1925 to 1930 the remote fuel fired heater made its appearance. With all heat generated externally to the oven, the heat supply fan became a necessity. The size of the fan was correlated to the size of the heater, economic factors being considered. In general, a greater amount of air was moved about in the oven and the tempera-

tures were considered to be fairly uniform. It was not long however before Industry had created products which demanded close temperature control and distribution.

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The difficulty in meeting these new demands plagued the remote heater manufacturers because the heater fans were too small, resulting in supply air to the oven at too high a temperature and creating hot spots in the oven. This difficulty was due to offering a standard heater and fan system without regard to process application.

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About 1935 it was recognized that certain BTU distribution factors which were satisfactory for baking of such items as foundry cores and kindred applications were not precise enough for baking finishes or varnishes and were entirely inadequate for precision baking of synthetics and like materials.

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It was recognized that the plus or minus distribution demand was dependent upon the recirculating fan size, heater capacity and operating temperature. For example, for a connected load of 100,000 BTU and a recirculating fan of 1000 CFM, dividing the former by the latter, we obtained the number of 100 BTU per CFM. By applying this process factor to a large number of different installations it was determined that the most uniform oven must have a factor range of 20 BTU per CFM in the difficult process of curing resin bonded articles; whereas a relatively crude process such as drying foundry cores could be handled satisfactorily with a factor as high as 200 BTU per CFM. These general rules are in widespread application in the Industry today with successful and satisfactory results.

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The developments which have promoted improvements in heating and drying processes in Industry in general have **not** been followed by corresponding developments in the wire enameling and insulating industries. The vast majority of today's wire enameling ovens bear a remarkable resemblance to the four walls and heaters of the early industrial oven. Fresh air is still permitted to leak into the wire slot in the bottom and escapes through a similar slot in the top. Heaters are located in the bottom or at intervals along the sidewalls. Ventilation in most cases is inadequate. Fires are frequent, but fortunately explosions are rare due to the open construction of the oven.

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A casual analysis of a typical wire enameling oven reveals a number of definite limitations as follows:

1. **A vertical enameling oven in which the heat is added along the sidewalls is a chimney and depends upon the natural induced draft for ventilation. This in turn depends on the physical size and height of the oven, the differences in absolute temperature inside and outside, the resistance to flow encountered and existing atmospheric conditions.**
2. **Being once through systems (that is systems in which the heated air is used only once, then exhausted) increasing ventilation by mechanical means such as exhaust fans requires a corresponding increase in the oven heating requirements. Economy of operation dictates that heating requirements, hence ventilation be restricted, consequently oven atmospheres are maintained at high energy levels.**
3. **The production rate is geared to the fixed ventilation rate of the oven. Increasing production involves a corresponding increase in energy level of oven atmosphere and the number of resulting tower fires.**
4. **The collection of oven atmospheres rich in condensable volatiles and solid materials is critical since the exit is exposed to the cooling and condensing action of adjacent room air. Condensing materials form obstructions to flow impeding the exhaust route.**
5. **Elimination of atmospheric pollution within and outside of the enameling area is difficult and requires high maintenance costs. The successful application of catalytic disposal units has done much to eliminate this annoying feature, but installation of these units represents a capital investment sometimes equaling the cost of the enameling oven and being external does not improve oven atmosphere.**
6. **Maintenance of uniform temperature across the width of the oven is critical, generally requiring special oven stringing in order to obtain acceptable bake on all wires.**

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To illustrate these points suppose we examine the operation of a typical once through vertical enameling oven. Let's assume we are enameling 20 lines, 6 coats each of 15 gauge formvar at a wire speed of 33 feet per minute in a 20 foot tower. The method of heating can be gas or electricity. If we explore the bottom slot of the oven with an accurate air flow instrument we find from 120 to 200 SCFM of air passing into the oven. This is the oven ventilation.

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For this illustration let's assume it to be 200 SCFM. The maximum oven temperature is found to be 800 degrees Fahrenheit somewhere near the top of the oven. The varnish consumed in one hour will be approximately 6 gallons of which 15% is non-volatile and the balance, solvents which must be driven off. The calorific value of the solvents varies somewhat with formulation. For this example we will select a modest 140,000 BTU per gallon and note that we have energy amounting to 6 x .85 x 140,000 or 714,000 BTU per hour liberated in the oven atmosphere. We have already noted that 50 BTU per SCF is an explosive mixture. In the example above the energy content amounts to 60 BTU per SCF which is well above the lower

	OVEN VENTILATION 200 SCFM		OVEN VENTILATION 950 SCFM	
	BTU	KWH	BTU	KWH
SIDEWALL RADIATION - -	43,000	12.5	43,000	12.5
COPPER ABSORPTION - -	64,800	19	68,500	19
SOLVENT EVAPORATION AND MISCELLANEOUS -	8,500	2.5	8,500	2.5
EXHAUST - -	151,000	44	739,000	216.0
	267,300	78	859,000	250.0

explosive limit. In order to reduce this to the 25% LEL required in general purpose industrial units, the oven ventilation must be increased to 950 SCFM. Now let's see what this does to oven requirements by examination of the following table obtained by simple heat calculations. See Table.

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The comparison is not as alarming as it appears because the auto ignition temperature of solvents commonly used in the enameling industry is between 900 and 950 degrees Fahrenheit which minimizes the danger of fires except in case of accidental contact of the wet wires with hot oven walls or the introduction of excessive quantities of solvent occasioned by lost or leaking enamel dies. However, the use of solvents having low auto ignition temperature such as alcohols, should be treated with caution.

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The recognition of these limitations and disadvantages of the once through system caused us to consider the application of practices adopted successfully elsewhere in Industry to the wire enameling trade. In 1951 the first vertical recirculating enameling ovens were placed in operation. These ovens were designed for wire size 24 to 15 AWG, inclusive. These were high volumetric recirculating, single zone units with catalytic incineration units installed in the recirculating stream.

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Solvent laden air from the working area was diluted with fresh air, the mixture heated to catalyst ignition temperature, drawn through the catalyst, a proper portion exhausted and the balance returned to repeat the cycle in the working area. These units were very successful in the baking of conventional oleoresinous types of enamel by drain and dip process, but the treatment was too harsh for high viscosity synthetic type enamels. In order to explain the term "too harsh" the results of a simple experiment which any of you can perform should be given.

By placing a piece of copper bus bar approximately 1/8 x 1/4" in cross section in a recirculating air stream, having a velocity of 250 feet per minute, at 700 degrees Fahrenheit, we discovered that the copper reached the polymerization temperature of approximately 360 degrees F. in 75 seconds. When this same copper bus bar was placed inside a radiating tube at like temperature, the time required to reach the 360 degree polymerization temperature was 120 seconds, indicating that the efficiency of heat transfer in the recirculating air stream @ 250 feet velocity is approximately 1.6 times greater than that of a radiating tube. This factor increases with the velocity of the recirculating air. The blistered enamel which appeared on formvar wires baked in these early recirculating ovens indicated that a gradual approach to temperature was necessary. Examination of thermo-couple explorations of a number of existing wire enameling ovens of the once through type confirmed our theories that successful production of this wire must be done by a gradual approach to polymerization temperature. The single zone recirculating vertical oven has a box-like temperature curve. That is, temperature at the bottom or entrance slot is approximately the same as the temperature at the top. Thus cold, wet wires entering the oven are subjected to the same treatment as dry wires at the top approaching polymerization temperature. Efforts to lower the temperature in the solvent evaporation zone were unsuccessful, and we concluded these single zone ovens were adaptable only to insulating materials requiring an abrupt rise to temperature.

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To adapt the high volumetric recirculating principle to vertical ovens we adopted the simple expedient of adding an individually controlled low temperature solvent evaporation zone at the bottom of the oven to the existing high temperature polymerization zone. Both zones are served by a common catalyst. Temperatures as low as 250 degrees Fahrenheit in the bottom zone and as high as 800 degrees Fahrenheit in the top zone are obtainable.

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A detailed heat balance and calculation of the operations of such an oven is beyond the scope of this article. However, some of the outstanding advantages obtainable should be enumerated.

1. **The presence of internal catalyst unit permits utilization of potential energy generated in the process.**
2. **Exhausts may be increased to acceptable standards, as high as 1200 CFM without sacrifice in operating economy.**
3. **The high heat exchange efficiency of the high velocity air stream promotes higher operating speeds.**
4. **Fuel costs are low.**
5. **Condensation and air pollution problems have been eliminated.**
6. **Initial costs are comparable to once through systems of equal capacity.**

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The ability to economically obtain wide-range proportioning control with gas burners, coupled with low unit fuel cost, makes gas an ideal heating medium for wire processing. We have found this particularly true in the applications mentioned above where rapid turndown and low thermal heads are sometimes required.

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The work which led to the development of the vertical recirculating enameling oven also taught us that these same principles could be applied to controlled atmosphere preannealers, ovens for curing glass binders and horizontal single zone ovens for enameling fine wires. A number of each type are in successful operation. Other uses for the principle are visualized and the trend is growing.

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Today's emphasis on increased output per unit of invested capital, the demand of civic authorities to eliminate the air pollution menace and the increasingly stringent requirements of state labor boards and insurance companies for safer, more healthy working conditions will eventually combine to bring about advances which have been adopted by Industry in general elsewhere.

Solution Coating of Copper Wire

by C. A. Litzler, President
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It is the purpose of this paper to describe in processing detail some of the design and engineering considerations that must be given to the problems involved in the precision application of electrical enameling solutions to copper wire.

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We are here concerned only with the application of multiple dips or successive coats of flexible solution finishes to continuous materials, either bare or fibrous wrapped, such as wire, cable or strand. The coatings may be either electrical insulating varnishes or enamels or decorative finishes such as paints or solution vinyl plastisols.

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Some of the design principles which are being discussed are common to many strand coating operations; however, this paper will confine itself to the application of electrical insulating materials on copper wire in the general size ranges of #8 gauge to approximately #30 gauge.

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The types of solutions which are applied in a system of this type are the conventional low viscosity enamels and higher viscosity polyvinyl formal enamels, solution nylon, solution silicone, solution teflon, solution polyvinyl chloride, or plastisol vinyl.

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All of these materials are mixed with or dispersed in a solvent or diluent vehicle, the solvent vehicle being principally xylol, mineral spirits naphtha, meta-para-cresol, etc.

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Generally, the viscosity ranges of solutions are in the order of 10,000 Centipoises to 50,000 Centipoises, or in the consistency of a light cream to a relatively heavy lubricating oil.

The author attended the John Carroll University. From 1931 to 1937 he was Vice President and Chief Engineer of the Morrison Engineering Company. He joined the Metal Equipment Company as Chief Engineer in 1938 and left to become President of Industrial Ovens, Inc. in 1940, from which company he resigned in 1952 to organize his present company, which specializes in coating and impregnating equipment for continuous web and strand materials as well as manufacturing a wide line of wire insulating machinery for the electric wire and cable industry.

Mr. Litzler's paper was prepared for presentation at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955.

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The solid content in the solution extends from 15% to 30%, except in the case of the polyvinyl chloride plastisols where the solids may be as high as 60% of the total solution.

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Polyvinyl chloride has been mentioned only as it applies to the flexible finish coatings. However, the handling of this solution is somewhat different from the application of insulating varnishes.

Overall Equipment Consideration

The general equipment requirements consist of the following major components which are mentioned in their order of use in a wire coating system (See Fig. 1):

1) **Letoff or Supply Reel Stands**
2) **In-Process Preannealer**
3) **Wire Straighteners**
4) **Application System**
5) **Evaporating and Polymerizing Furnace**
6) **Capstan and Takeup Units**

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Some general comments concerning their use are in order.

1) Letoff Stands

The letoff reel stand must be a suitable structure for the smooth and tensioning unwinding of the wire or wires from the individual reels.

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If possible, the grouping of the reels should be such that the time

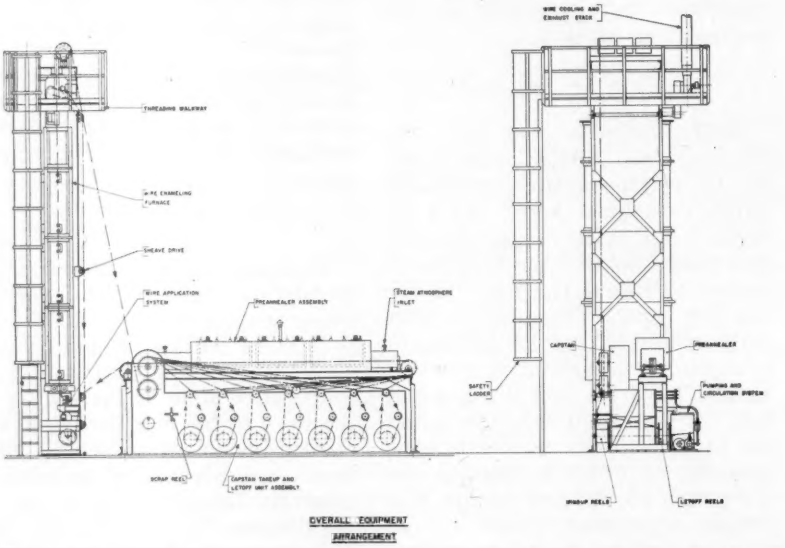


Figure 1.

of making a splice or a weld is reduced to the essential minimum.

2) In-Process Annealer

For wire plants with relatively large production, it is proving economical and beneficial to the product to continuously anneal the wire as it is being processed. The immediate requirements are for scale-free, bright annealing. Both superheated steam or dry gas are used as a protective atmosphere. Electric or indirect-fired gaseous fuels are used as the primary heat source.

3) Wire Straighteners

After preannealing, the wire is straightened and the usual method of straightening is the offset roller-type straightener. They are mounted at the entrance or the exit of the preannealer.

4) Application System

The wire next passes into the application system which is mounted beneath the furnace. The incoming wire is passed through the application system and is coated, thence passes vertically upward through the furnace, through a short holding zone, through the cooling zone, around the top sheaves and diagonally back to the rear of the furnace for the second pass.

★ ★ ★

Gang-type or cross-threading is normally employed for all types of enamels, although for vinyl chloride coatings, individual and consecutive stringing is used.

5) The Evaporating and Polymerizing Furnace

After coating, the wire enters a vertical, electric or gas heated furnace, usually equipped with a hold zone and cooling zone.

★ ★ ★

The furnace on the larger sizes of wire is vertically arranged, although it might be inclined at an angle from the vertical, or it may even be horizontal. By far, the largest number of furnaces are vertical arrangements and, for this reason, the vertical furnace is to be considered.

The cooling and exhaust zones are positioned directly on top of the furnace.

★ ★ ★

The cooling zone, obviously, removes heat from the wire before its passage over the top sheaves. This prevents pickoff and buildup of insufficiently dried or polymerized coating.

★ ★ ★

The exhaust provides for removal of the explosive solvent vapors emanating from the coatings.

6) Capstan and Takeup Unit

The wire, after receiving its required number of passes to build the insulation thickness to the point required, proceeds continuously through an easy threading "S" wrap capstan which propels the wire smoothly through the entire system.

★ ★ ★

From the capstan, the wire proceeds through suitable level winding devices to a takeup which is powered with torque motors, controlled torque mechanical drives, or a simple slip clutch.

★ ★ ★

We are not concerned here with the mechanics of the unwinding or winding except to state that the wire must be paid off smoothly, propelled smoothly and must be properly tension wound on the finish reel. The finished package must be firmly wound.

★ ★ ★

The tensions through the system must not exceed that which will produce elongation of the strand or reduction in its gauge size, taking into consideration the elevated temperatures in the polymerizing furnace.

★ ★ ★

We are mainly concerned with the application system itself, including sizing dies, the enamel conditioning system, the polymerizing furnace, the exhaust air requirements and the in-process annealing operations.

The Open Atmospheric Pressure Application System

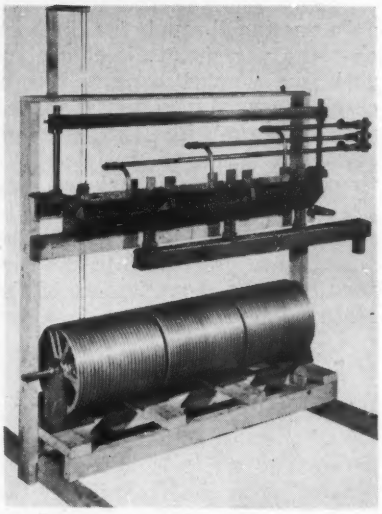


Figure 2. * * * * * * * *

All synthetic enamels, such as polyvinyl formal, nylon, silicone and solution teflon, are applied to the wire in application systems which, in general, have the appearance of the system indicated in this figure.

★ ★ ★

The complete assembly consists of a pressure system which distributes enamel to various banks of individual application slots and an accurate level control for the maintenance of proper enamel level so that the enamel contact with the wire will be thorough and adequate.

★ ★ ★

Over the applicator unit proper is the sizing die system in which the solid floating dies are accurately positioned relative to the wire. These dies remove the excess materials and accurately meter the solution coating concentrically around the wire. There is an overflow system through which the excess material passes into a sump and thence back to the enamel conditioning system.

★ ★ ★

As the wire passes around the lower interlocking guide sheave, it is contacted by an accurately grooved guide roller directly beneath the application tank. The purpose of this guide sheave is to center and accurately steady the

wire to reduce wire vibrations to a minimum.

★ ★ ★

In passing through the top wire slot, the wire is in direct contact with the enamel bank which is carried upward in a conical-shaped mass until the wire passes through the die. The mass is restricted by the die orifice which allows only the proper quantity of material to pass through with the wire. The wire thence proceeds into the furnace for the polymerization of the coating.

Enamels of Higher Viscosity

The position of the die and the top of the enamel bank in the application system is directly dependent upon the viscosity of the enamel and its surface tension.

★ ★ ★

Lower viscosity materials require less application time and space than do higher viscosity materials. Accordingly, the block holding the pins upon which the dies are supported may be adjustable so that the height of the dies might be altered to suit the enameling conditions.

★ ★ ★

Materials such as polyvinyl formal and nylon require a dimension of approximately 5″ from the top of the enamel to the centerline of the die. Thinner materials, including paint, require considerably less height. It is desirable to reduce the height of the bank to a minimum to prevent exposure of the solution to air with resultant loss of solvent through surface evaporation.

★ ★ ★

The flow of solutions from the circulating and filtering systems to the application system is controlled by flow valves mounted in the supply line. In normal application on a 12-end, 12-coat system, the application rate is in the order of four gallons of circulated enamel per hour. Variable speed pumps are used to allow suitable adjustment in the circulation rate. See Fig. 3.

Enclosed Pressure System

Applications of relatively high viscosity material to copper wire are sometimes accomplished by the enclosed method of application. A cross-section of such a system is indicated in Figure 4.

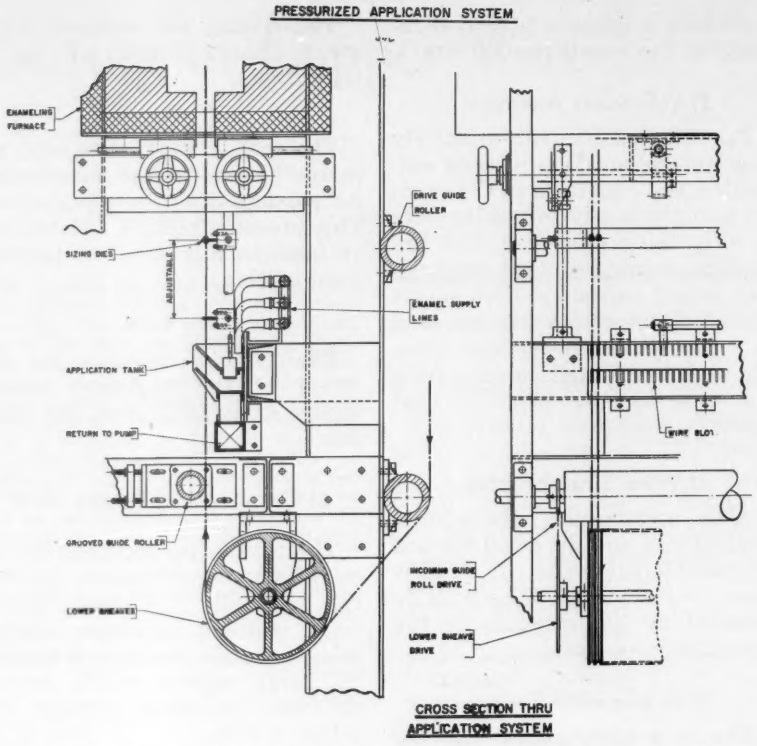


Figure 3.

This system consists of a completely enclosed tank containing the coating compound through which the wire passes.

★ ★ ★

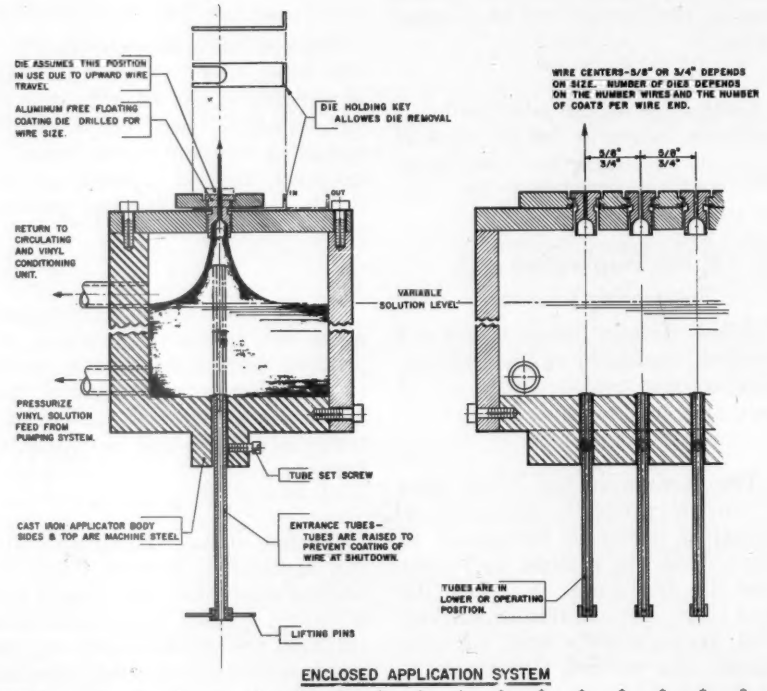

DIE ASSUMES THIS POSITION IN USE DUE TO UPWARD WIRE TRAVEL
ALUMINUM FREE FLOATING COATING DIE DRILLED FOR WIRE SIZE.
DIE HOLDING KEY ALLOWES DIE REMOVAL
WIRE CENTERS-5/8" OR 3/4" DEPENDS ON SIZE. NUMBER OF DIES DEPENDS ON THE NUMBER WIRES AND THE NUMBER OF COATS PER WIRE END.
5/8" 3/4"
IN
OUT
RETURN TO CIRCULATING AND VINYL CONDITIONING UNIT.
VARIABLE SOLUTION LEVEL
PRESSURIZE VINYL SOLUTION FEED FROM PUMPING SYSTEM.
TUBE SET SCREW
CAST IRON APPLICATOR BODY SIDES & TOP ARE MACHINE STEEL
ENTRANCE TUBES— TUBES ARE RAISED TO PREVENT COATING OF WIRE AT SHUTDOWN.
TUBES ARE IN LOWER OR OPERATING POSITION.
LIFTING PINS
ENCLOSED APPLICATION SYSTEM

Figure 4.

The depth of the solution within the container is adjustable through a variation of the level control height. The wire passes through the entrance tubes which, in normal operating positions, are as shown.

★ ★ ★

The inside diameter of the tube is slightly larger than the outside diameter of the largest wire size that is to be run in the system.

★ ★ ★

The upward speed of the wire prevents the solution from running through the tube. When the wire stops, the tube is pushed manually upward until the open end of the tube is above the coating solution level.

★ ★ ★

After passing through the solution, the wire passes vertically upward and through a hardened sizing die which is built to the cross-section indicated in the figure. The cross-section shown provides concentric coating of vinyl plastisol of approximately 60% resin and 40% diluent.

★ ★ ★

The circular dies fit into the mounting holes in the top of the application unit.

★ ★ ★

The die is equipped with a shoulder which communicates with a counterbore in a separate steel member running the entire length of the application system. This member is equipped with slots on the bottom face and into these slots are positioned die holding keys as indicated in the figure. With the key in the fully "up" position, the die is held in operating position and with the key pulled out the die can be easily removed from the die holder for inspection, cleaning or redrilling.

★ ★ ★

The circular relief in the die body proper, which is in contact with the key, is provided with vertical clearances so that in operation, the upper thrust of the coating raises the die and aids in its self-centering.

★ ★ ★

On this type of system, gang threading of the wire is not used. Each end of wire is run through the required number of dips successively. For operation flexibility, because of color differences in the coating and wire size difference, each end is separately threaded and provided with individual adjustable capstan and takeup units.

★ ★ ★

It is easy for the operator to see which ends are running because when the wire stops, the die drops downward in position level with the top of the application system.

★ ★ ★

An enclosed system of this type must be provided with a relatively high pressure circulating system as the pressures are approximately 5# above atmospheric pressure. The circulating system is usually equipped with viscosity control, temperature control, variable volume pumps and automatic filtering devices.

Because of the nature of plastisol coating compounds, special large area rotary filtering screens are employed. The circulation rate through the screens must be maintained, otherwise clogging of the filter openings presents an operating nuisance and often causes shutdowns. These compounds are difficult to handle and precise temperature, viscosity and circulation rate controls must be used. (Fig. 5)

★ ★ ★

Another type of completely enclosed pressure system is that which utilizes pressures up to 20# to deliver the enamel to the wire. It consists of a series of jets with volume control, which jets deliver the enamel in the proper volume to the application slot. The proper volume is that amount of solution which is picked up by the wire in its vertical travel through the wire slot.

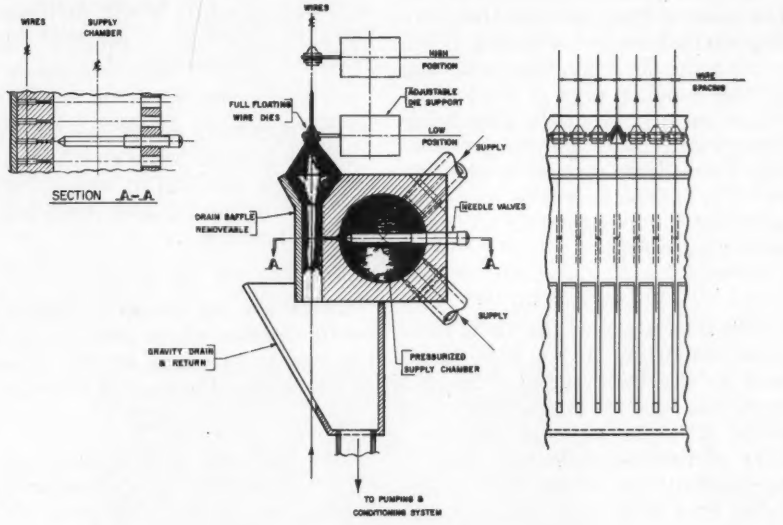


Figure 5.

The circulation rate of vinyl chloride resin solutions must be relatively slow. When the circulation rate is rapid, there is the danger of particle size breakdown with resultant loss of electrical and abrasion resisting qualities. If the circulation rate is too slow, sedimentation and caking of the vinyl solids cause wire breakage and production shutdowns.

Various die arrangements have been tried, experimentally, and the circular floating aluminum die was found to produce the most concentric coatings.

★ ★ ★

One advantage of this system is the small amount of enamel exposed to the air.

Sizing Die System

Let us now consider the solid die system of coating sizing.

The solid die system consists essentially of a one piece solid circular aluminum die, as shown on Figure 6.

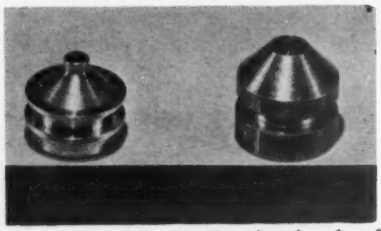


Figure 6.

These dies are made in several sizes, the larger of the two handling wires from #8 to approximately #14 gauge and the smaller size handling from #15 to #30 gauge. The dies are made of soft aluminum and are light in weight to reduce the inertia required to center them in their guide pins.

★ ★ ★

The dies are positioned on two hardened horizontal pins and they are carried in the circular relief around the die body. The overhang of the holding pins is kept to a minimum to prevent the pins being accidentally bent, thereby preventing them from properly and accurately supporting the dies and allowing the dies to float with the wire movements.

★ ★ ★

The inlet angle of the die is relatively important. It has been found that as the inlet angle of the die increases up to a maximum of about 48°, the self-centering feature of the die increases. This is particularly true when the dies are being used with high viscosity materials.

★ ★ ★

It has also been found that the length of the lead-in angle and the straight metering section of the die are relatively important. The longer the metering section length, the more there is a tendency for the dies to oversize the coatings. In certain coatings, this condition builds up a frothy deposit around the discharge end of the die. This deposit builds up, eventually breaks off, and deposits itself on the wire. It dries in the furnace and in the next dip, it clogs the next die and ultimately causes the wire to break.

★ ★ ★

Dies with the small inlet lead angle do not operate satisfactorily with heavy enamels; however, they are sometimes used on low viscosity solutions.

★ ★ ★

It has been found experimentally on plastisol compounds that a circular relief on the inlet lead of the die allows for space for evacuation of the excess material that is drawn into the lead-in cavity by the wire velocity. This condition prevents sedimentation and build-up in the die throat.

★ ★ ★

With any given inlet angle and length of die metering section, the higher viscosity coatings handle and coat better with greater dimension from the top of the solution to the die itself. This dimension is normally 5″ for heavy solutions down to as low as 1″ for very low viscosity materials.

★ ★ ★

The operating advantage of the solid die is that, being circular and conical in its lead-in shape, the viscosity of the solution itself self-centers the die.

★ ★ ★

There are no ridges or angular configurations which tend to shift the die to one side of the other in relation to the axis of the wire.

★ ★ ★

The viscosity and surface tension of the coating is effective in lifting the die off the pins and, as the viscosity forces work equally in all directions, the conical lead-in provides for very close coating concentricity.

★ ★ ★

There are several types of solid dies used for very fine wire on synthetic enamels in foreign countries. These dies are so constructed that the flow of the enamel into the apex of the die is diverted and this force is used to raise the die off its solid base. Such dies require drilling of exceedingly fine holes, ports and passage ways for the materials. They are difficult to maintain but produce very concentric finishes on very fine wires.

Drilling of Solid Dies

The drilling of the dies is, naturally, of critical importance. It is essential that the pilot lead cone be accurately centered on the axis of the die. The actual drilling is accomplished by either air or electrically driven high-speed precision die drill presses. (See Fig. 7.)

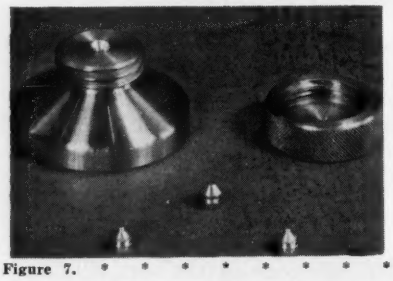


Figure 7.

Conventional die drilling methods are used. The soft aluminum material allows for the rapid drilling of small holes without danger of drill breakage. The figure shows the clamping and centering jig used for holding the die during drilling and reaming.

★ ★ ★

In cases of half gauges or very fine wire sizes, special reamers are used. The holes are first drilled and subsequently reamed to size. The dies are stamped or marked in the conventional fashion and any die drilling department can maintain the die in precise shape.

★ ★ ★

For best results, an optical comparator is employed in accurately gauging the hole size. About 500,000 feet of wire is produced by each die before re-machining is required. Additionally, too, the dies are inexpensive.

★ ★ ★

Figure 8 shows a sample of drill dimensions which are used on solution nylon for the wire sizes indicated. This appears on page 1208.

★ ★ ★

The coating is applied in six consecutive passes and there are three sizes of dies employed. As a general rule, it has been found that smaller amounts of solution per

pass provide a smoother coat and higher wire speeds than heavier coatings applied in fewer numbers of passes.

TYPICAL SOLVENT LOADS

WIRE SIZE	WIRE SPEED F.P.M.	GALS. PER HOUR	NO. OF ENDS OF WIRE
15 GA.	29	4.0	20
18 GA.	42	3.7	20
20 GA.	47	3.1	20
25 GA.	60	2.9	20

SOLUTION NYLON COVERED WIRE

SOLIDS - 25%
SOLVENT - 75% - META PARA CRESOL (CRESYLIC ACID)

SOLVENT BOILING RANGE - 396° F.

VAPOR/LIQUID RATIO 398 @ 450° F

Figure 12.

The primary and alleged objection to a solid die, especially on the finer wire sizes, is the difficulty of passing splices and kinks and the difficulty of wire breakage. This condition, however, is not a serious one and proper enameling procedure minimizes these production shutdowns.

★ ★ ★

Butt welding the wire is employed to join the ends together and, if the weld is properly made, the flash from the weld is not excessive and presents no difficulty in its passage through the die.

★ ★ ★

There are several methods of electro-welding of splices, one of these being done in a manner in which the wire to be welded is contained within a ceramic tube. This tube contains the weld flash and limits its diameter to that of the smallest die opening in the system. After welding, the ceramic tube is merely broken from around the wire.

★ ★ ★

Kinks in the wire are invariably due to improper handling in either the wire mill or in the letoff operation. Proper care in handling usually eliminates these causes of wire breakage.

★ ★ ★

A closed kink cannot be removed, but minor bends are removed in either the annealing operation or in the roller straightener prior to the actual enamel application.

Enamel Conditioning System

In a solid die system, the electrical quality of the coating and the speed at which it is applied is directly affected by the viscosity of the solution. (See Fig. 9)

★ ★ ★

Because the interior diameter of the die is fixed and the outside diameter of the wire is fixed, the annular opening between the two becomes an orifice through which the material is metered. With any given percentage of solids and solvents in the solution, the thickness of the dried coat will be uniform. It becomes desirable to maintain the solvent/solid ratio at a constant rate and, thereby, maintains the viscosity constant in the solution.

★ ★ ★

The viscosity is affected adversely by changes in the solid/solvent ratio and the ambient temperature. Normally, in any modern system, separate pumping, circulating, filtering and temperature controlling systems are employed. A system of this type is shown in the figure.

★ ★ ★

It has been found on many installations that the enamel returned to the pumping system contains relatively small percentages of copper dust which are literally minute shavings resulting from and being carried over from the drawing operation. It is apparent that this metallic contaminant will reduce the insulating quality of the coating.

★ ★ ★

In some extreme cases, these copper slivers are carried by the enamel through the die and are actually embedded and fused into the wire coating itself. This condition causes complete electrical test failure and the wire must be scrapped.

★ ★ ★

In an actual production run of six weeks, as much as ten grams of copper solids were removed from the filter well of a pumping and filtering unit.

★ ★ ★

Continuous enamel filters are provided with filtering screens or discs with filter openings under .005″ in diameter.

★ ★ ★

In any given enameling system, enamels will vary in viscosity. Most enamel systems operate with enamel temperatures in the order of 110°F. to 120°F. Because of this temperature, there is a hastening of the solvent evaporation and, ac-

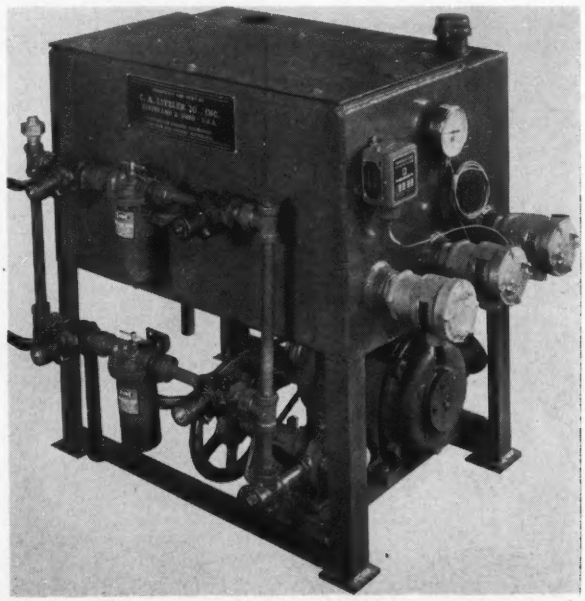
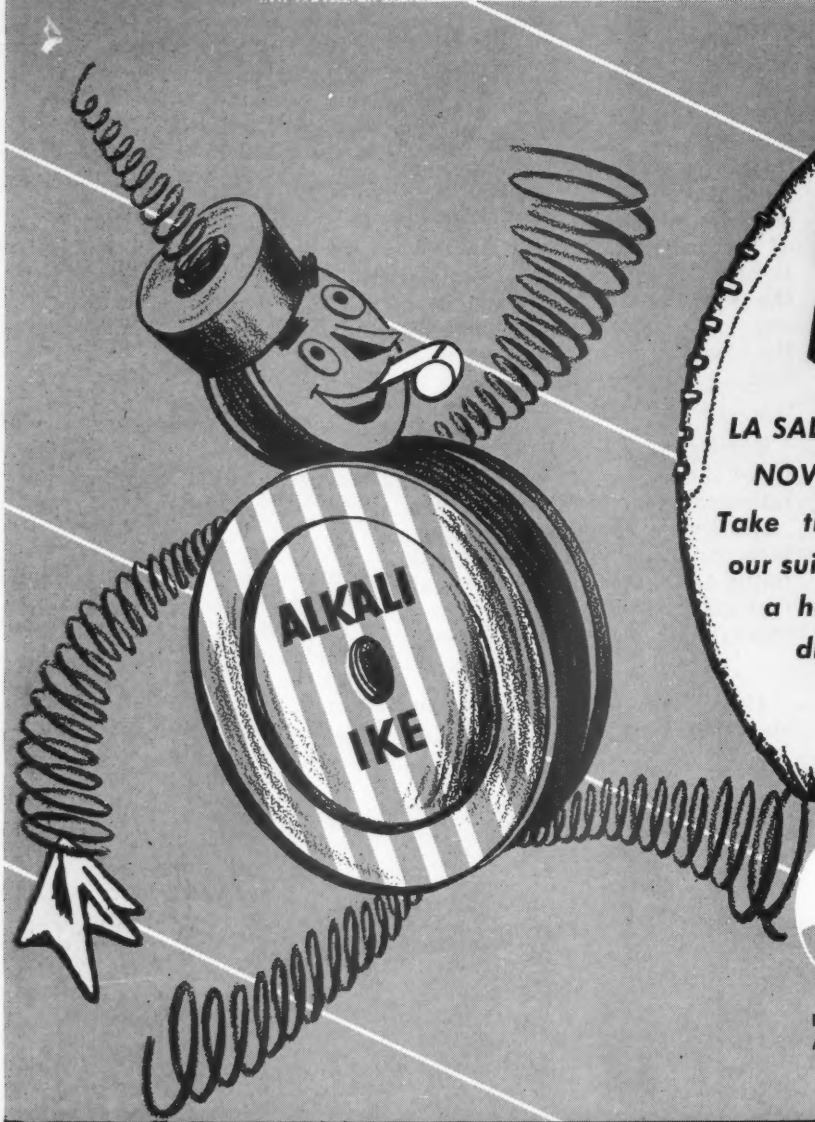


Figure 9.

OUR GOAL



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cordingly, the amount of material exposed to the atmosphere must be kept to a minimum.

Circulation Rate of the Enamel

The circulation rate of the enamel is usually in the order of three complete system changes per hour for a six-dip, twelve-wire system.

★ ★ ★

If it is required to maintain true viscosity control, it becomes necessary to add solvent to the mix at a rate to compensate for that solvent which is evaporating through atmospheric contact. This is done through the use of a viscosemeter and a variable volume solvent pump. True viscosity control is expensive and requires rather elaborate equipment.

★ ★ ★

This elaboration is not required on the average installation. It is sufficient to circulate the enamel at a given rate and add previously mixed enamels to which an additional amount of solvent is added. This extra solvent compensates for that which is lost in the enamel already circulated.

★ ★ ★

Suitable bypass arrangements are made in the pumping system to provide for extra circulation of newly added enamel to provide an intimate mixing contact between the enamel in the application system and the enamel in the storage tank. This mixing method, when properly executed, provides a homogeneous mass of solvent and solids of uniform fluidity condition.

The Solvent Evaporating and Polymerizing Furnace

Let us now consider the general heating patterns that are applicable to the proper evaporation of the solvent and the polymerization of the coating solvents. (See Fig. 10)

★ ★ ★

This figure shows the schematic vertical cross section of an electrically heated wire enameling tower showing the relative placements of the heating elements with notes as to the distribution of the total energy in relation to the control system.

Elements on alternate sides of the tower are wired in series with approximately 40% of all elements in the furnace on temperature control. The controls can be either saturable core reactor type control or "on-off" control.

★ ★ ★

60% of all of the elements are not connected to any control system but are equipped with individual disconnect switches so that it is possible to obtain any reasonable temperature gradation within the system.

★ ★ ★

When the furnace is in operation under a stabilized thermal condition, the greatest heat load occurs in the lower one-third of the furnace. Accordingly, 46% of the total heat energy is released in that portion of the furnace. This large initial thermal heat load is obviously due to the absorption of heat by the incoming cold wire, the relatively large amount of sensible heat used in the evaporation of solvent and the absorption of further heat to warm up the air which infilters through the work slot opening at the bottom of the furnace.

★ ★ ★

Approximately 80% of the solvent is evaporated in the first third of the tower height. In the second third of the tower height, the final remaining 20% of the solvent is evaporated. This evaporation of solvent and the continuing absorption of heat by the copper wire and the coating solids absorb approximately 30% of the total heat energy.

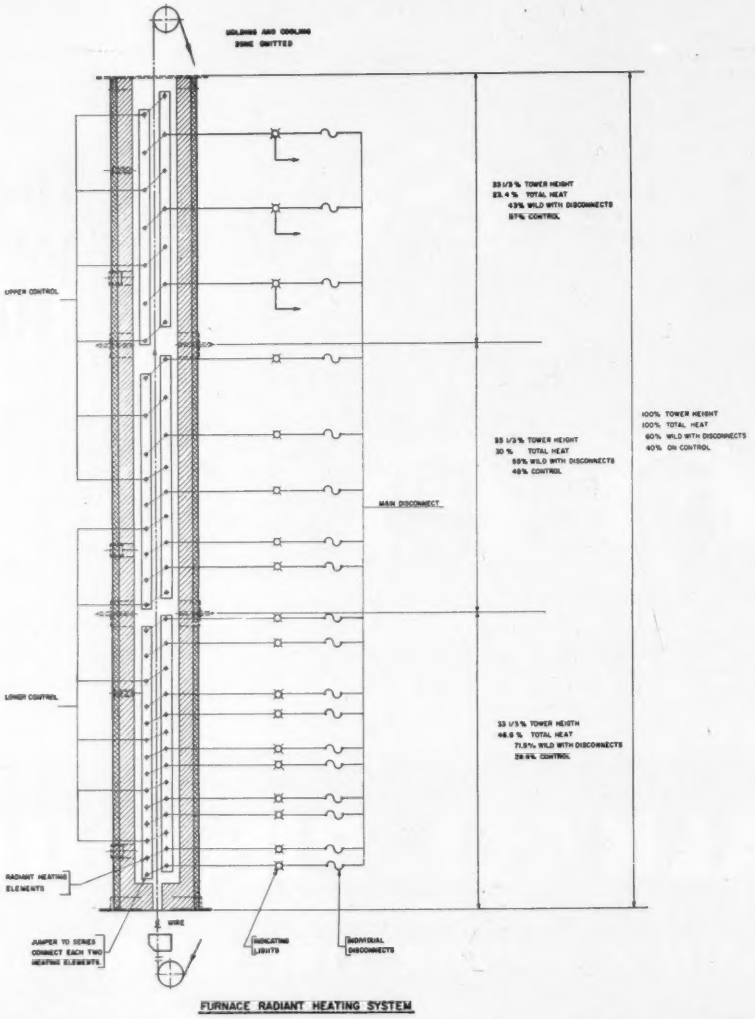


Figure 10.

After solvent evaporation is complete, the wire continues to absorb additional heat but at a diminishing rate and, correspondingly, only 23% of the total heat is released in the top third of the tower. These figures include a constant heating load for the absorption of heat flow through the furnace brickwork and radiation from the outside of the furnace casing.

★ ★ ★

The spacing of the elements becomes a very important part of the design of the tower. The normal chimney effect, due to the tower height and to small amounts of vertical up-drafts within the tower, tends to even out radiated temperature differences across the width of the tower. The variable space of the elements is done to counteract some of the chimney effect of the tower and to provide a uniform, although variable, heating pattern along the vertical wire pass line.

★ ★ ★

To allow for a relatively wide range of requirements for different heating patterns, the individual disconnect switches are either "on" or "off", as is required, to provide this suitable pattern for the evaporation of the solvent at a given moderate rate.

★ ★ ★

If the solvent is evaporated too rapidly, blistering and pitting of the coating occurs. If the operating temperatures are too high, there is the possibility of surface drying of the enamel. This condition, in turn, causes blistering and formation of craters due to expanding of entrapped solvent which subsequently causes a rupture of the surface film.

★ ★ ★

Under these operating conditions, if it were not for a flexible tower heating arrangement, changes must be made in the solvents used to alter their boiling range or their evaporation rate to suit the tower heating pattern.

★ ★ ★

For an example of the relative temperature effects produced by two different element "on" and "partially off" patterns refer to Fig. 11.

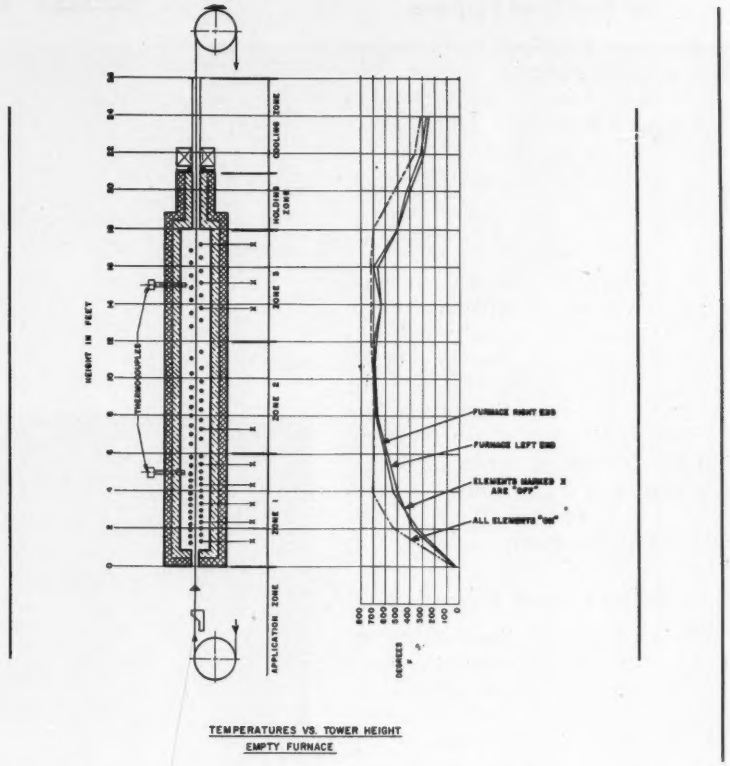


Figure 11.

A considerable amount of experimental work has been done on this subject and one set of the curves has been shown.

★ ★ ★

This figure depicts three temperature curves taken at two foot intervals throughout the height of the 18-foot tower. The solid lines indicate furnace temperatures at the right and left hand side with the elements marked "X" disconnected from the line. The broken curve indicates the temperature pattern when all of the elements were connected to the line.

★ ★ ★

These tests were taken in an empty furnace so that it would be possible to determine the net effect of the element operation. It can be assumed that these curves may change slightly when the furnace is in actual operation and running wire.

★ ★ ★

If the wires in the furnace are cross-strung, there is a tendency for the temperature to drop on the incoming side of the furnace on which the wire originally enters the system.

★ ★ ★

There is a tendency for the ends of the furnace to operate at lower temperature because of the radiation from the end of the furnace casing proper. This condition is alleviated by the use of taper wound heating elements. These heating elements have a greater watt density at the ends of the elements as compared to the center of the elements. This greater watt density extends in from the ends of the furnace approximately 12″ from each side.

★ ★ ★

The greater heat release at the element ends, which compensates for end wall radiation loss, also provides for the relatively close operating temperature difference between the right and left end of the furnace.

★ ★ ★

In some smaller plants, an enameling installation is required to produce different types of coating and the need for flexibility of heating pattern is very apparent.

The Gas Fired Furnace

On some gas fired enameling or coating installations, rather elaborate means have to be used to effect a different temperature gradation from that which the furnace has by its own inherent design.

★ ★ ★

Temperature patterns on gas-fired units can be effected by the installation of low velocity exhaust systems throughout the tower height or through the use of properly spaced radiant type line burners. This type of construction, however, induces secondary hazard problems which must be overcome by a careful thermal balance in the system.

Solvent Vapor Exhaust

In keeping with the safe operation of the installation, the need for a properly sized exhaust is necessary. This is particularly true of gas fired installations but it must also be recognized and considered on radiant installations. A typical solvent exhaust load on a 20-end system is shown in Fig. 12 on page 1203.

★ ★ ★

In this case, the solvent exhaust requirements reached a maximum of four gallons per hour which, under National Board of Fire Underwriters' Code Requirements, indicated an exhaust load of 650 cubic feet of air per minute at 70°F. for operation of the furnace at conditions under 20% of the lower explosive limit concentration of the solvent being used.

★ ★ ★

The removal of exhaust air from the furnace is critical because of the natural tendency of heated solvent vapors to rise, their proximity to high furnace temperatures and because of the necessity of maintaining low air velocity and minimum air turbulence throughout the tower.

★ ★ ★

Most exhaust systems remove solvent vapor from the very top of the furnace usually over the holding zone. The exhaust must be taken from the system at low air velocities and turbulence to prevent vibration in the wire.

★ ★ ★

The solvent vapors carry with them minor amounts of minute particles of coating solids and the deposition of these solids, together with some solvent residue, present a fire hazard and an operating nuisance. There are several ways in which this exhaust problem might be handled and the summary of the most common methods is shown in Fig. 13.

★ ★ ★

Of the four systems indicated, #2 is the most simple. It consists of a simple exhaust duct slot carrying along the wire opening, this slot communicating with a suitable exhaust fan which delivers the exhaust air to a stack. A simple in-

(*Please turn to page* 1282)

TYPICAL DIE DRILLING DIMENSIONS

	NOM. BARE WIRE	AVERAGE INSULATION THICKNESS	NOM. DIA. OVER INSUL.	NO. OF INDIVIDUAL COATS	NO.	DIA.	NO.	DIA.	NO.	DIA.
20 GA.	.0320	.0026	.0346	6	2	.035	2	.037	2	.039
19 GA.	.0359	.0027	.0387	6	2	.040	2	.042	2	.044
18 GA.	.0403	.0029	.0432	6	2	.042	2	.044	2	.048
17 GA.	.0453	.0030	.0513	6	2	.052	2	.054	2	.056

OPERATING SPEED = WIRE DIA. SIZE x 2♦

SOLUTION: NYLON SOLIDS - 18%-20%
META PARA CRESOL - 82%-80%

OPERATING TEMPERATURE - 700° F. MAX.

Figure 8.

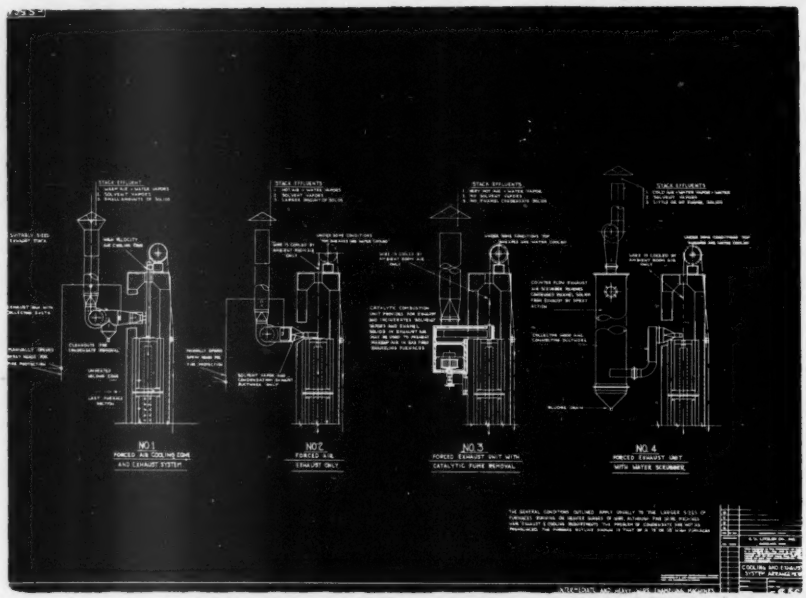


Figure 13.

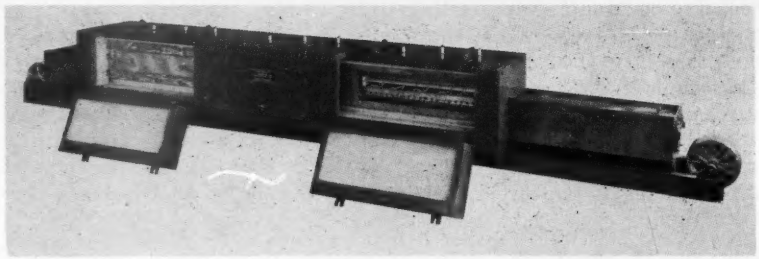
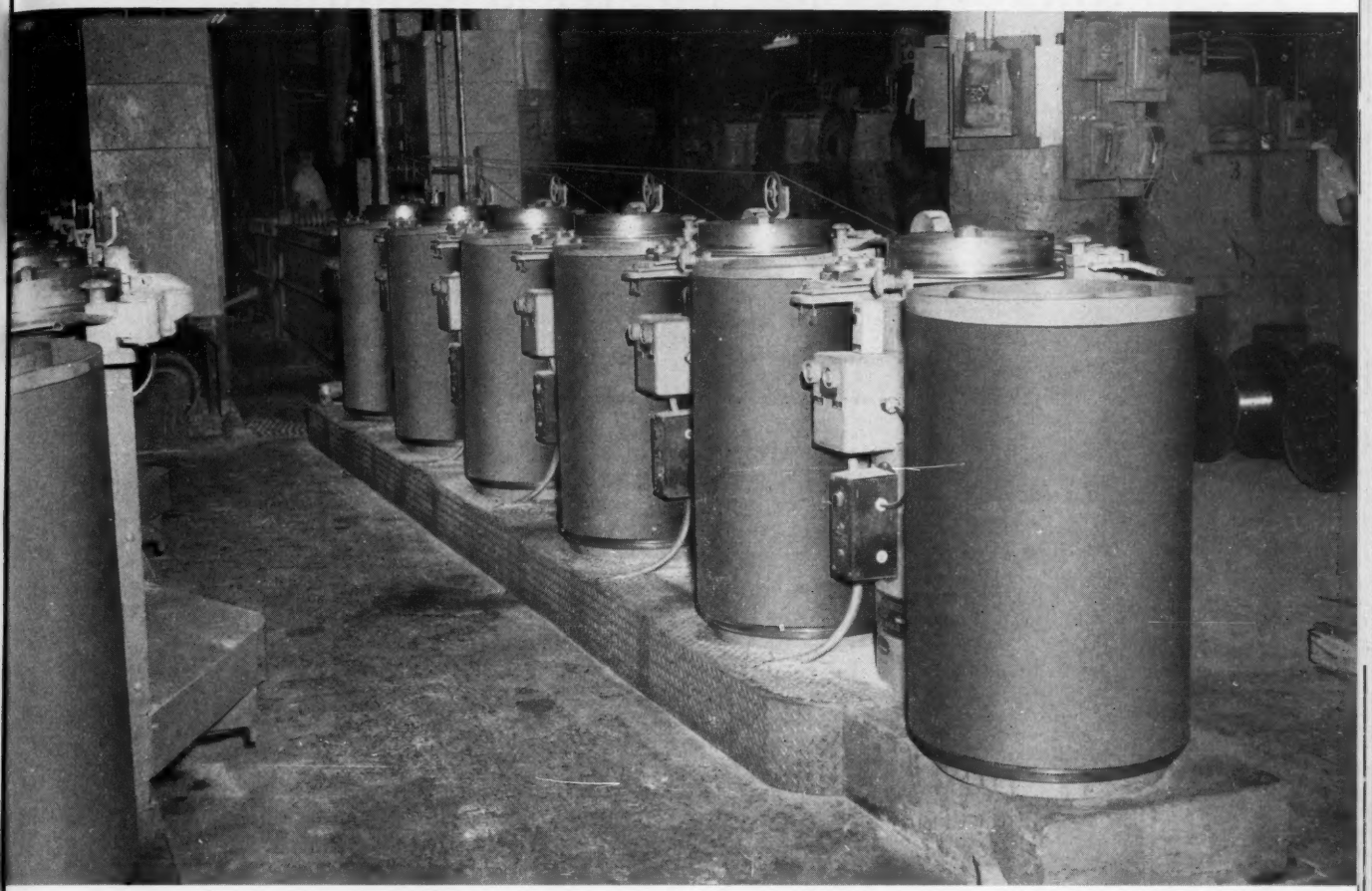


Figure 14.

Coulter & McKenzie DRAW·PAK *Equipment*



Continental Can Company Payoffpaks illustrated

DRAW-PAK PAYS EXTRA DIVIDENDS

The customer required a take-up for electro-tinned copper wire which would assure *trouble-free* payout to high speed drawing machines. Coulter & McKenzie immediately provided the solution with two Series "500" DRAW-PAK units arranged in banks of six capstans each.

These DRAW-PAK machines not only solved the original payout problem by eliminating frequent breaks and tangles, but they extended the length of the run and yielded *seven additional major improvements* in the product and operation. Look at the extra dividends which the DRAW-PAK paid:

1. **A full number draw is taken during take-up operation.**
2. **Tinning speed increased from 300 to 500 feet per minute.**
3. **Size of take-up package *doubled* — 250 lbs. to 500 lbs.**
4. **Higher degree of tension control assures more uniformity in the electro-tinning process.**
5. **Number of strands per plating tank increased from 4 to 6.**
6. **Fewer "lost" strands in tanks due to breaks.**
7. **25% to 30% increase in efficiency due to longer continuous runs.**

If you want to learn more about how the Coulter & McKenzie DRAW-PAK can help you, write to us today.

See us at the Annual Convention of the Wire Association, Chicago, November 14-17.

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SINCE 1843 BRIDGEPORT 3, CONNECTICUT, U. S. A. INCORPORATED 1881

Ductility Tests for Electrical Conductors

by Louis Boleraski, Research Engineer
Electrical Engineering Section
Department of Metallurgical Research
Kaiser Aluminum and Chemical Corporation
Spokane, Washington

The author prepared this paper for delivery before The Wire Association at its Annual Convention in Chicago, Ill., November 14-17, 1955

The development of new high strength aluminum alloys for aerial electrical conductors has necessitated more sensitive and reliable techniques for measuring the ductility of wires. Tests have been developed for more accurate quality control and for determining actual handling characteristics, as they would affect installation of the wire. Now, with the co-ordination of electrical conductivity measurements, tensile strength and ductility tests, a conductor alloy's fundamental characteristics, durability and practicability are readily pre-determined in the laboratory prior to any costly experimental cable fabrication and installation.

★ ★ ★

In developing a conductor metal, mechanical and electrical test results pertaining to the more important ultimate properties of the wire are determined and established. Subsequent alloying and treatment variables are investigated by electrical and mechanical testing until the desired composition and temper of the wire are achieved. The wire is then subjected to various types of ductility tests which have proven to be invaluable. Practical tests such as reverse bend, torsion twist, torque-wrap and wrap-back are conducted to determine the feasibility of using standard installation practices, as well as conventional techniques that may be employed by the average lineman in possible emergencies.

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Following is a brief description of each of the ductility tests and the apparatus, some of which is of new design, used for conducting the tests.

Reverse Bend Test

The reverse bend test jig, (Figure 1) consists of two bench vises bolted together, one on top of the other. A novel feature of this arrangement provides bends made around the test material radii as well as bends made in contact with identical material.

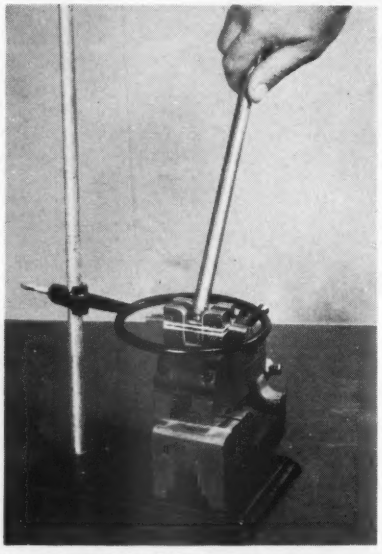

Fig. 1—Reverse Bend Tester

The bottom vise, a Palmgren No. 30, is "V" grooved vertically to a maximum opening of 3/8 inch at the center of the stationary jaw. The specimen is clamped in the groove to insure rigidity of the wire, except for motion at the point of test.

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The upper vise, a Yankee No. 922, has two ½-inch thick plates, each containing a rectangular center notch at the top ¾" wide by 1" deep. These plates are bolted to the inner sides of the jaws. The plate jaws contain three horizontal "V" grooves of different sizes that accommodate a maximum wire diameter of ⅜ inch. Short lengths of the same wire being tested are held in these grooves by means of rubber bands and thus form the bend jaws. The specimen is lightly clamped between the two horizontal bend jaw samples and bent 90° to either side of its original position. The horizontal wires are held with rubber bands to facilitate shifting so that subsequent specimens may be bent against new, unmarked radii.

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The specimens are bent by means of a ½" x 12" steel tube containing a fiber bending tip. A fiber tip 1½" long, drilled to the approximate diameter of the wire under test and bevelled 45° for ¼", is selected and inserted in an end of the tube prior to test. The fiber tip prevents galling and nicking of the test specimen during test. It also limits bending of the specimen to the area at the horizontal sample jaws.

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The test set-up is placed on the base of a ring stand. A 5-inch ring is clamped to the vertical rod in a position so that the test jaws are in the center; as the specimen is bent, in either direction, motion of the steel tube is restricted to a maximum arc of 90°. The number of completed 90° bends are noted at the time of failure. The ring is clamped to the vertical rod at different levels for wires of other diameters.

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Figure 1 shows an overall view

of the bend tester with a specimen positioned for testing. Figure 2, a bar chart, presents the average reverse bend test results and the 90% probability limits of ten specimens tested.

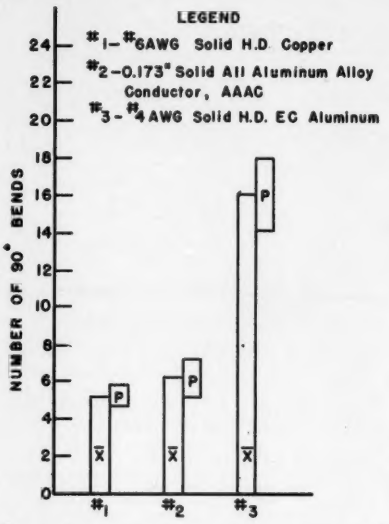

Fig. 2—Reverse Bend Tests

Torsion-Twist Test

Torsion tests are made in a jig (Figure 3) composed of two Jacobs

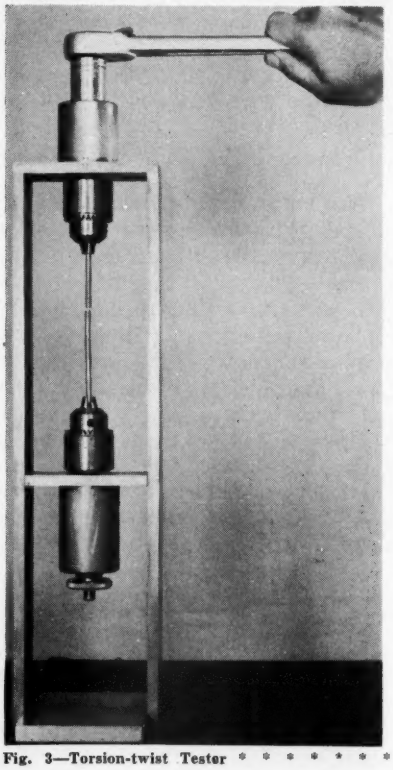

Fig. 3—Torsion-twist Tester

drill chucks, No. 2B, secured between two vertical 3/8" x 2" steel straps separated by 4 inches. The chucks are spaced 6 inches apart on vertical centers. The novelty of this tester is that while the specimen under test is twisted, tensile forces, created by contraction of the wire, are eliminated by means of an integral tension spring in the lower chuck, just strong enough to keep the specimen straight.

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The upper chuck is positioned in a ball bearing race to afford a free-running rotary motion.

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The lower chuck is positioned in a stationary plate between the steel straps in a pressure fit bearing and supported on a tension spring. The spring tension is equivalent to the weight of the chuck. Six-inch long specimens are secured between the chucks. The lower chuck is tightened first. Before tightening the upper chuck, the lower chuck is pressed upwards and held approximately 1/8 inch above its normal position until the specimen is tightened moderately. On tightening, the chuck jaws produce a compressing force on the sample. Bowing and kinking of the wire specimen is prevented by compression of the spring in the lower chuck. During test, the spring has a maximum travel of 1/4 inch. When the chuck jaws are tightened, actually 4 1/4 inches of specimen remains under test.

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The upper chuck is rotated, with a socket wrench at a uniform rate of 2 r.p.m., and the number of 360° turns completed at the time of failure is recorded.

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Figure 3 shows an overall view of the tester with a specimen in position. The test specimen is shown after failure, demonstrating the shortening of the sample during test.

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Figure 4 graphically exhibits the average torsion test results and the 90% probability limits of ten specimens tested.

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Manual tests may be conducted with the test jig in an upright position. A motorized tester in a horizontal plane can also be used.

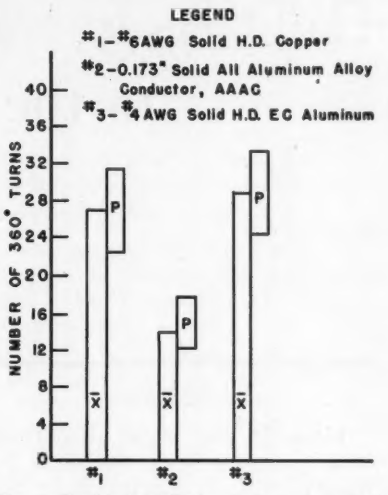

Fig. 4—Torsion-twist Tests

Torque-Wrap Test

Torque-wrap is a test to determine the torque required to wrap the specimen around its own diameter. This test readily evaluates the ease of wrap-back deadending a conductor by determining the required torque.

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The torque-wrap test jig (Figure 5) is much the same, physically, as the torsion tester. The chucks

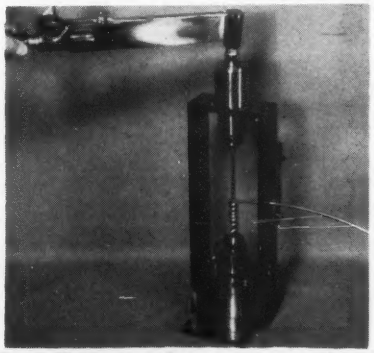

Fig. 5—Torque-wrap Tester

are also six inches apart on vertical centers. Both chucks are seated in ball bearing races to eliminate friction caused by the rotating chucks. A three-inch diameter flange, containing a 1/4 inch hole, 3/8 inch from the rim, center tapped, is screwed on the threaded shaft of the lower chuck. One of

(*Please turn to page* 1297)

Factors Affecting the Characteristics of $Ca(OH)_2$ In Suspension, With Special Reference to the Wire Drawing Industry

by T. C. Miller, Technical Director
Industrial Sales Division
National Gypsum Company
Buffalo, New York

Introduction

Lime is the most important coating material in the wire industry. This is illustrated by the fact that we have received service requests on lime problems from more than twenty industrial plants during the past two years. Lime as a coating material has suffered at the expense of other materials in the past, principally because of the lack of knowledge of its characteristics under mill operating conditions. But, the interest in a $Ca(OH)_2$ suspension, contrary to some belief, is on the increase because more knowledge of its behavior has resulted in its acceptance as a more convenient coating material.

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Investigation of the peculiar characteristics of $Ca(OH)_2$ suspensions during the past two years, through the cooperation of mills requesting service has revealed certain precautions which must be exercised to maintain the $Ca(OH)_2$ at a suitable physical level. An introduction to this was given in my article "The Importance of Lime in Wire Drawing," published last August. Fundamental data was presented on factors involving the choice of a type of lime proving most satisfactory for wire drawing. The present paper is a presentation of data on the changes in the physical structure of $Ca(OH)_2$ under certain conditions in the wire mill.

★ ★ ★

The slaking of CaO with water and the suspending of commercial

Thomas C. Miller

A paper prepared for presentation at the Annual Convention of The Wire Association in Chicago, Ill., November 14-17, 1955.

The author was educated at the University of Tennessee and the University of the South. He has worked for various lime and cement concerns as a chemical engineer and served on the research staff of the Armour Research Foundation, where he was supervisor of the Masonry Materials Section. He joined National Gypsum in 1951.

$Ca(OH)_2$ in water as well as the maintenance of temperature in the wire dipping bath are important in the preparation of a suspension. But these are not the most vital problems in maintaining a coating suspension of $Ca(OH)_2$. The problem of maintaining a satisfactory bath is by no means simple—in fact, it is much more complicated than many of us realized even two years ago.

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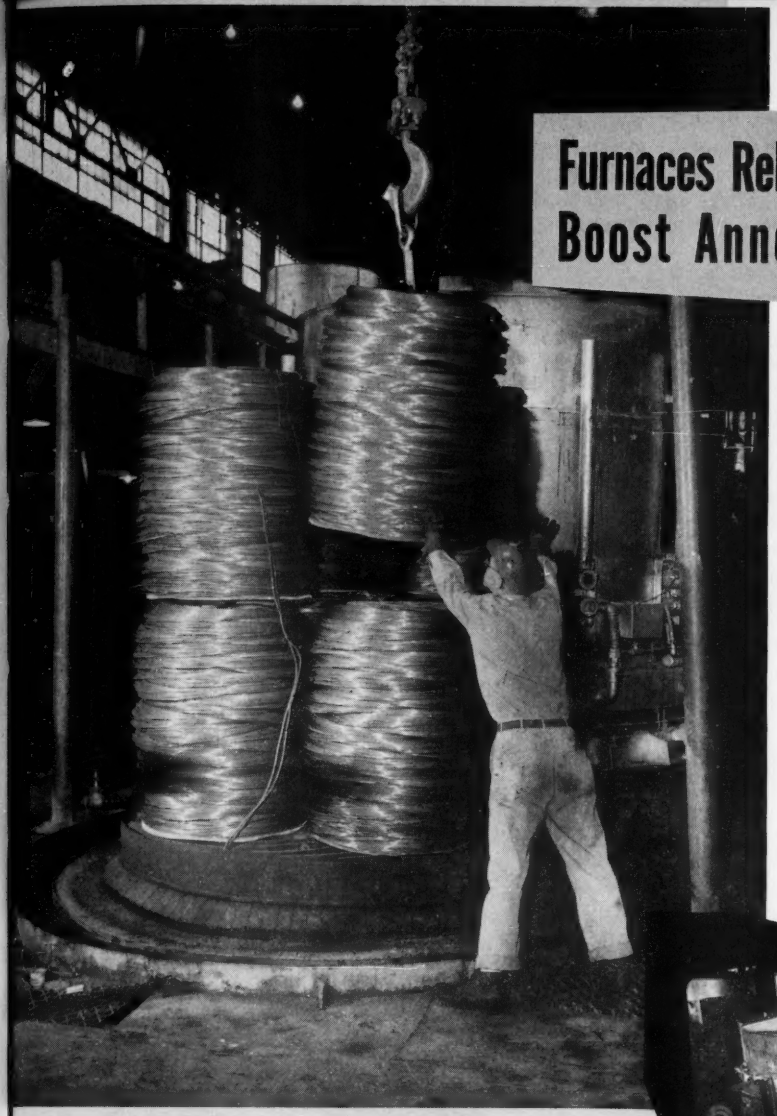
It is our contention that quick lime slaked under ideal conditions, produces a $Ca(OH)_2$ suspension more ideally suited to wire drawing than commercial hydrated lime. This does not mean that hydrated lime cannot be used for wire drawing. Quite the contrary, commercial $Ca(OH)_2$ can be, is being and will continue to be used with success. But, results from the use of the Blaine air permeability method for testing fine materials over a period of years have revealed that freshly slaked quick lime has a higher specific surface than commercial hydrated lime. And, we believe the benefit of a higher specific surface from freshly slaked quick lime offers greater potential for an improved coating as a grease carrier.

★ ★ ★

The major lime problem confronting the wire drawing industry is the increased amounts of coarse particles being produced in $Ca(OH)_2$ suspensions which result in very inferior coatings. These coarse particles continue to increase in size and quantity with daily use of the bath until agitation no longer will keep them in suspension. The large particles settle out and the weaker suspension contains too little $Ca(OH)_2$ to produce a lime coating. The cause for these coarse particles had not been understood and their presence had been on the increase in a greater number of plants. Repeated requests for services in studying the problem by many mills has offered the opportunity to investigate the conditions leading to a solution of its cause. Such a study has resulted in at least one method for its prevention.

Furnaces Rebuilt for High Convection Boost Annealing Production by 75%

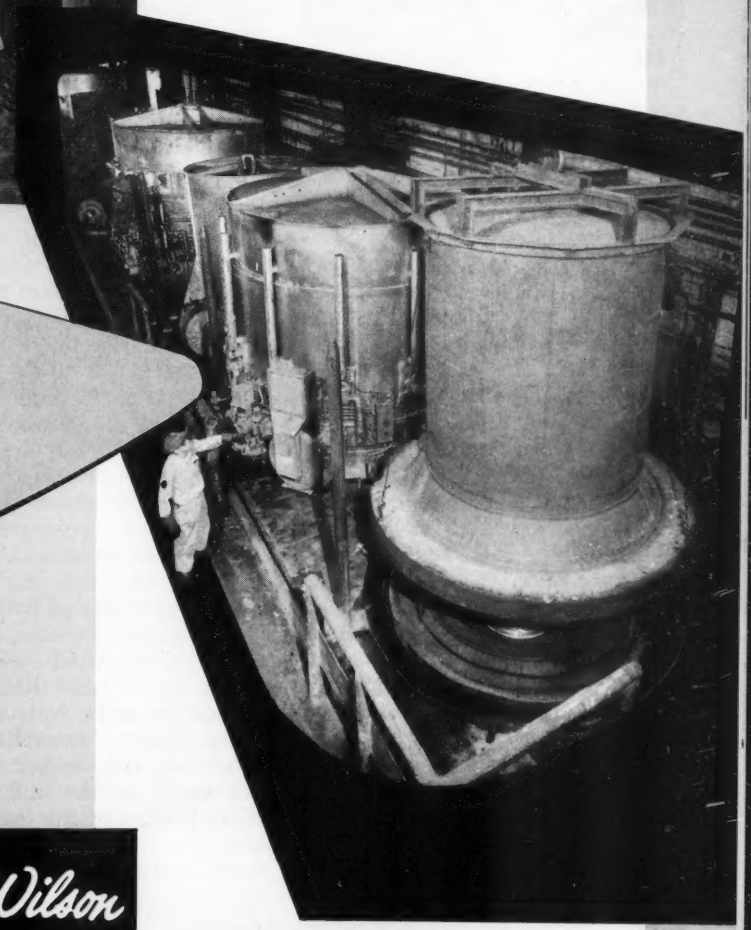


Northwestern Steel and Wire Co. finds the addition of Lee Wilson High Convection System plus "O" Tubes Pays Big Dividends.

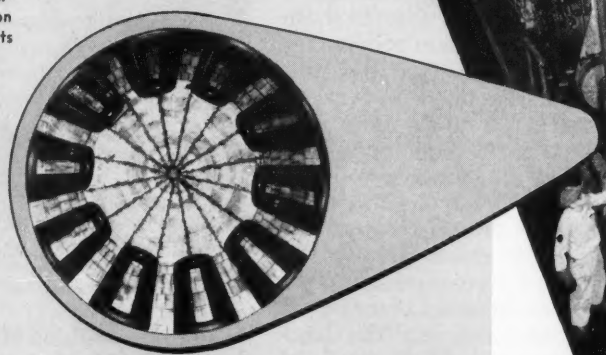
Realizing the advantages of high convection annealing for wire coils, Northwestern Steel and Wire called in Lee Wilson engineers to look over their operation.

It was suggested that Northwestern convert their present bell type furnaces to high convection. "O" tubes were installed in the furnace to double the fuel input and the recirculating fan high convection units with 20 HP drives were installed in the bases. The result of this inexpensive operation was a tonnage boost from 2000 lbs. per hour to 3500 lbs. per hour.

Why not call in a Lee Wilson engineer to discuss rebuilding your equipment and gain the same advantages that Northwestern has realized? They're the nation's most experienced high convection people.



ting a charge on converted furat Northwestern. Lee Wilson neers high convection units fan drives from 7½ HP 25 HP with deliveries from 00 to 25,000 cfm.



View from underside of furnace showing how "O" tubes completely surround each charge. This type of radiant tube permits at least double the fuel input to any size furnace.

Lee Wilson

ENGINEERING COMPANY, Inc.

20005 West Lake Rd., Cleveland 16, Ohio

Under our present increased production rate, it is necessary to accelerate the drying of wire coating by maintaining higher bath temperatures. It appeared early in this investigation that higher bath temperatures promoted the formation of coarse $Ca(OH)_2$ particles, which in no way is associated with any particular grade or type of commercial CaO or $Ca(OH)_2$. Their presence did not appear to indicate an inferior lime product. A solution to the problem then became one of pure or fundamental research. Since dipping tanks in wire mills are not suitable for such a study, it became necessary to make the investigation on laboratory size equipment.

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It has been found that $Ca(OH)_2$ in suspension is very sensitive to temperature changes from about 102°C and above. At these temperatures, any heated body in contact with a suspension of $Ca(OH)_2$ causes a crystallization of pure hexagonal crystals on the surface of this body. In the early stages of crystallization, the crystals form in a very uniform manner on the surface of the body. These crystals continue to grow outward from the surface of the body forming elongated needle-like projections. Part of these projections or needles break away from the main body of the crystal, either by heating or cooling or by the turbulence caused by boiling, and become mixed with the amorphous $Ca(OH)_2$ in suspension. Under heating and cooling cycles of operation, the crystals appear to be laid down in laminations as though the cooling and heating had some effect upon the rate of growth. Laminated layers more than ⅛" thick have been deposited under certain conditions in a 24 hour operation. The amount of crystals separating from the heating coil has been found to be relatively high, as denoted by the amount retained on a 325 mesh sieve or by a rapid increase in the specific surface of the $Ca(OH)_2$ passing this sieve. The presence of crystals in the material finer than 325 mesh has been proven optically. The crystals which break away from the coil show evidence of becoming mixed with the amorphous $Ca(OH)_2$ forming a nucleus to which the amorphous form adheres and grows into relatively large spheres of soft amorphous $Ca(OH)_2$.

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The aim of this investigation was to determine the temperature at which these crystals begin their growth and to measure the rate of growth under various temperature ranges. It is recognized that the results reported in this paper are based upon simple laboratory equipment and any rate of deposition determined may or may not be comparable to that encountered in actual mill operation. However, the results of this laboratory investigation have been found to relate closely with certain operating techniques in commercial mills. In every mill visited where steam coils were used, evidence of crystal growth was noted. In one particular mill, the production of crystals was at such an accelerated rate that the residue consisted almost wholly of plates of crystal $Ca(OH)_2$ with very little spherical amorphous $Ca(OH)_2$. The heat had converted the $Ca(OH)_2$ to crystals. Data for the rate of growth in commercial mills has not been determined.

Apparatus

In the majority of commercial dipping tanks, heat for the bath is supplied by a steam coil or pipe submerged in the $Ca(OH)_2$ suspension. These pipes of various designs generally rest on or near the bottom of the tank, parallel to the sides or diagonally across the tank. Steam is supplied to these pipes or coils from a few pounds of pressure for closed end pipes to several pounds pressure for pipes offering resistance through a series of perforations. The laboratory experimental bath consisted of a stainless steel, four-liter beaker. Copper and stainless steel tubing ¼" outside diameter were formed to make coils of 41" effective length extending to the bottom of the beaker. The inlet and outlet of the coil were well above the top of the tank to facilitate a connection to the steam source and to equip the exit with a needle valve for maintaining pressure throughout the coil. The coil contained no perforations because dilution of the $Ca(OH)_2$ suspension was to be avoided. The study was limited to the influence of the temperature and the length of coil used was chosen to give maximum length to cover the bath area and provide the greatest heating surface.

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To make the apparatus as simple as possible, a steam system was designed from two household pressure cookers connected to a common steam outlet. Each pressure cooker was equipped with a thermometer for observing steam temperatures, and the common steam junction was equipped with a pressure gauge. Steam could be taken from one boiler for interrupted study or from both boilers alternately for continuous operation. Pressures of 5, 10, and 15 psi, automatically controlled by the boiler regulators, were used in the operation. A needle valve was installed in the exit end of the steam coil to regulate the rate of discharging condensed water and steam so that a close balance of coil and boiler could be maintained at all times. The assembled system is shown in Figure 1.

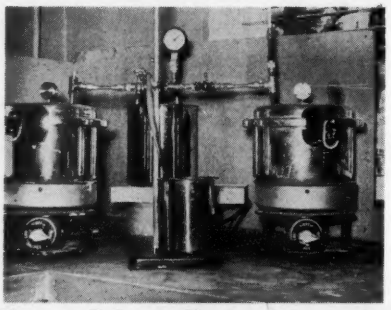

Figure 1—Bath assembly for steam pressure studies.

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An assembled apparatus for the direct heating of a suspension of $Ca(OH)_2$ with live steam is shown in Figure 2.

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Preliminary tests substantiated our heat theory on physical changes in $Ca(OH)_2$, and therefore we did not confine the study entirely to steam heating. An electric heated bath was designed

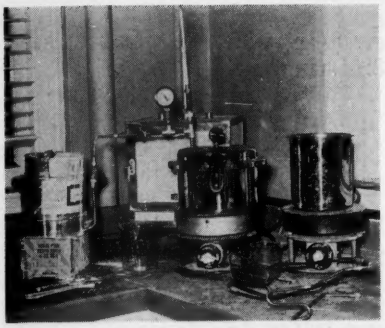

Figure 2—Bath assembly for direct use of steam.

using a 1000 watt copper coil, regulated with a bi-metallic thermo regulator to automatically supply just enough current to maintain the bath at 100°C (212°F). The effective length of this heating coil was 20″.

★ ★ ★

The modified Blaine air permeability apparatus was employed to study the specific surface of all solid materials.

Materials

$Ca(OH)_2$ suspensions were prepared from pebble quick lime. The suspension was produced by adding a weighed amount of lime to the required amount of water at 100°C (212°F). When hydration was complete, the $Ca(OH)_2$ suspension was sieved through a 325 mesh screen and the suspension diluted to give a 6% suspension.

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A 100 ml sample of cooled suspension was filtered on a 2½″ Buchner funnel. The $Ca(OH)_2$ was washed with five 10 ml portions of alcohol and dried with five 10 ml portions of ether. All alcohol and ether were evaporated with infra-red heat and the sample finally dried in an electric oven at 100°C (212°F). The weight of the $Ca(OH)_2$ was determined from the 100 ml sample, which was controlled at 6g $Ca(OH)_2$ per 100 ml of suspension.

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The specific surface of the $Ca(OH)_2$ was determined on the dried sample with our modification of the Blaine air permeability apparatus. All $Ca(OH)_2$ used for this study had a surface in excess of 44,000 cm^2/g.

The specific surface of the $Ca(OH)_2$ in the heated suspensions was found to have increased by a relatively large amount because of the presence of minute crystals. This increase in surface should not be confused with the increase caused by disintegration of amorphous $Ca(OH)_2$ in the circulating system. The free energy of a centrifugal pump is sufficient to cause some increase in surface. As an example, a 39,735 cm^2/g $Ca(OH)_2$ suspension was found to increase in specific surface to 48,778 cm^2/g by pumping, at room temperature, for 69 hours.

Operation of Tests

Two series of tests were made with the submerged steam coil. One series was conducted under interrupted conditions to permit cooling and heating cycles. The other series was conducted on a continuous basis. The steam boiler was brought to operating pressure before steam was admitted to the coil. The bath was then brought to boiling by the steam coil alone. The heating cycle was timed when the bath reached boiling. The cycle for any tests was arbitrarily chosen at 12 or 24 hours of total operating time.

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The electric heated bath was operated intermittently for a total of 24 hours.

Operating Data and Results

A bath of 2300 ml of a 6% suspension of $Ca(OH)_2$ passing a 325 mesh sieve, at a specific surface of 44,988 cm^2/g, was heated with the steam coil at 5 psi continuously for 12 hours. The specific surface of the solid in a sample of the suspension at the end of the test was found to be 45,078 cm^2/g, or practically unchanged during this period. The residues on the 200 mesh sieve and the 325 mesh sieve from the entire bath were 1.12g and 0.8g respectively and the crystalline $Ca(OH)_2$ adhering to the coil was 1.78g. The total residue was 3.08g. This residue, identified optically in Figure 3, represents only 2.23% of the total $Ca(OH)_2$ used, but the interesting phenomenon is that

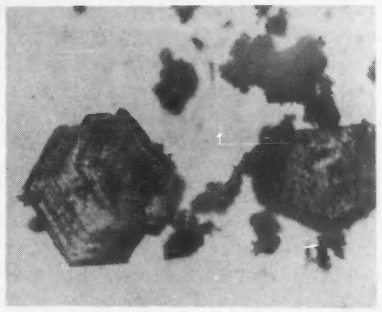

Figure 3—Crystalline $Ca(OH)_2$ produced at 5 psi continuously for 12 hours. Approximately 500X.

this residue was grown on the steam coil during the 12 hour steaming period and the rate of deposition was 1.15g/ft^2/hr.

★ ★ ★

The suspension passing a 325 mesh sieve was recharged to the tank and the coil again heated for a total period of 23 hours by intermittent operation. The residue at the end of this test on the 325 mesh sieve was 3.85g and from the coil was 3.55g. The total residue was therefore, 7.40g or approximately 5.48% of the total $Ca(OH)_2$ present. This represents a growth rate of 1.44g/ft^2/hr which is only slightly higher than the rate of growth on continuous operation. It can be assumed that this slight increase may be attributed to the crystals already in the sieved suspension from the continuous operation that were just small enough to pass the openings on a 325 mesh screen and may have continued to grow during this subsequent test.

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Another lot of -325 mesh stock $Ca(OH)_2$ suspension was heated intermittently for 24 hours with steam at 10 psi. The specific surface of the dry $Ca(OH)_2$ from the -325 mesh suspension before the test was 44,988 cm^2/g. The specific surface of the dry $Ca(OH)_2$ from the suspension at the end of the 24 hour test was 49,368 cm^2/g. The dry $Ca(OH)_2$ from the portion of the suspension passing a 325 mesh sieve had a specific surface of 49,750 cm^2/g. The gain of 4,370 cm^2/g surface during the test is attributed to the growth in $Ca(OH)_2$ crystals and the close agreement between the $Ca(OH)_2$ from the entire sample (49,368

cm^2/g) as compared with the $Ca(OH)_2$ from the -325 mesh portion (49,750 cm^2/g) indicates the presence of minute crystals finer than a 325 mesh. The residue from the 325 mesh sieve was 4.35g, and the residue of crystals from the coil was 17.68g giving a total residue of 21.98g or 15.9% of the $Ca(OH)_2$ present. The rate of growth of crystals at 10 psi was 4.09 $g/ft^2/hr$. This rate is 2.84 times as great as the rate of growth at 5 psi. The coated coil is illustrated in Figure 4. The residue removed from the coil is shown in Figure 5. Optical studies of the crystals are shown in Figures 6 and 7.

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Another lot of the $Ca(OH)_2$ suspension having a specific surface of 48,303 cm^2/g was heated intermittently at 15 psi for 24 hours. At the end of this test period, the specific surface of a sample of the entire suspension was 48,941 cm^2/g. The portion of the suspension passing the 325 mesh sieve had a specific surface of 53,594

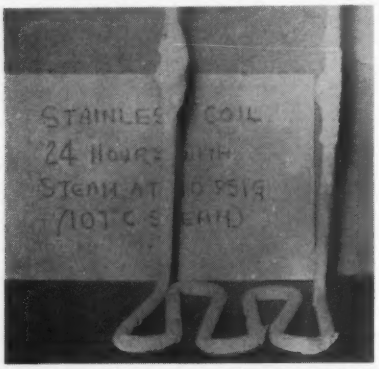

Figure 4—Stainless steel coil after 24 hours at 10 psi.

cm^2/g. This is an increase of approximately 4,000 cm^2/g surface during the test and compares favorably with the specific surface of the suspension at the end of the test at 10 psi. However, the -325 mesh portion of the suspension at 15 psi was 3,844 cm^2/g higher in surface than the corresponding sample at 10 psi, which again indicates a still greater amount of minute crystals of $Ca(OH)_2$ in the suspension finer than the 325 mesh screen. The residue from the entire sample on a 325 mesh screen was 19.07g and the crystallized material adhering to the coil was

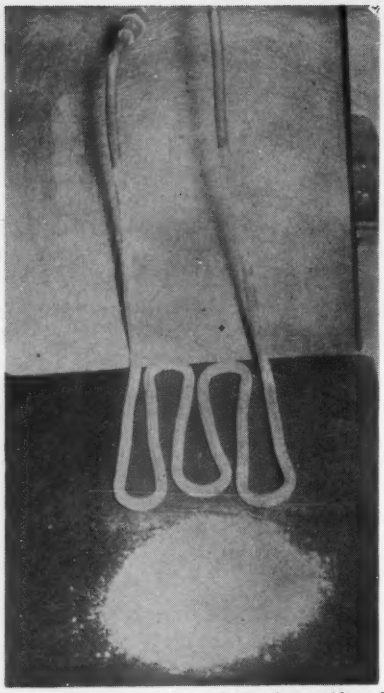

Figure 5—Stainless steel coil showing residue of crystalline $Ca(OH)_2$ removed.

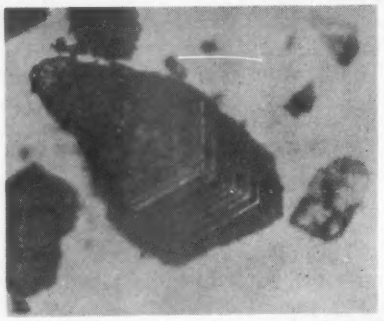

Figure 6—Crystalline $Ca(OH)_2$ produced at 10 psi intermittently for 24 hours. Approximately 500X.

Figure 7—Crystalline $Ca(OH)_2$ produced at 10 psi intermittently for 24 hours. Approximately 500X.

5.22g. The total weight of residue was 24.29g or approximately 17.6% of the total lime present. The percentage of residue at 15 psi was approximately 2% higher than the total residue at 10 psi. The rate of growth of crystals was 4.52 $g/ft^2/hr$, which is approximately 3.14 times the rate at 5 psi and 1.13 times the rate at 10 psi.

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Another test was made on a different supply of $Ca(OH)_2$ tested intermittently at 10 psi. In this case, 117.8g of CaO was slaked in 2200 ml water at 100°C. The residue was allowed to settle and the suspension was decanted from the residue. The suspension was then diluted to 2500 ml which was sufficient to give approximately a 6% suspension. A sample of 100 ml from this final dilution was found to contain 5.88g of $Ca(OH)_2$. The specific surface of the $Ca(OH)_2$ was 44,070 cm^2/g. After 24 hours of intermittent heating at 10 psi, the $Ca(OH)_2$ was found to have increased in specific surface to 49,080 cm^2/g. The portion of this suspension passing a 325 mesh sieve was found to contain $Ca(OH)_2$ having a specific surface of 54,699 cm^2/g. The crystallized material larger than 325 mesh from this suspension weighed 19.23g and the amount of crystallized material retained on the coil was 7.18g. The total residue retained on the 325 mesh sieve and the coil was 26.41g or 16.95% of the total $Ca(OH)_2$ present. The rate of growth, on 41″ of effective length of coil, was 4.92 $g/ft^2/hr$ which was 1.2 times greater than the sieved sample tested previously at 10 psi under the same conditions. This increase is attributed primarily to the fact that the suspension was not passed through a 325 mesh sieve to remove relatively large particles of $Ca(OH)_2$ (larger than 325 mesh).

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A bath of stock $Ca(OH)_2$ suspension, having a surface of 44,988 cm^2/g, was heated in the electric heated bath intermittently for a total time of 24 hours. The suspension at the end of this test was found to contain $Ca(OH)_2$ having a specific surface of 48,981 cm^2/g or an increase of approximately 4,000 cm^2/g. This increase in specific surface compares with the increase at 10 psi and 15 psi. The suspension passing a 325 mesh sieve was found to contain

$Ca(OH)_2$ having a specific surface of 48,737 cm^2/g, which is almost identical with the unscreened suspension. The weight of material on the 325 mesh screen was 7.7g and the crystallized material on the The total residue larger than 325 coil shown in Figure 8, was 12.33g. The total residue larger than 325 mesh was, therefore, 20.03g or 14.52% of the $Ca(OH)_2$ present. The crystal growth on the coil with an effective length of 20" was 7.65 $g/ft^2/hr$. This rate of growth is 1.52 times greater than the maximum growth at 10 psi and 1.7 times the growth at 15 psi using the same stock solution of $Ca(OH)_2$. An optical study of these crystals is shown in Figure 9.

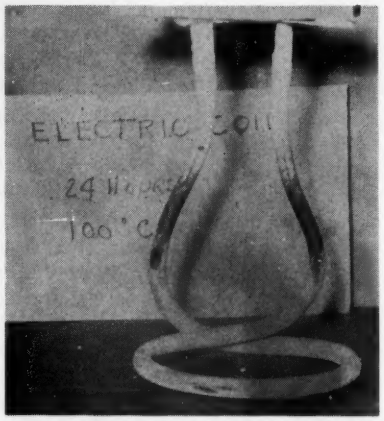

Figure 8—Electric coil with deposit of crystalline $Ca(OH)_2$ after 24 hours. Bath temperature automatically controlled just to 100°C. * * *

It has been established that the rate of growth of $Ca(OH)_2$ on a heated surface is proportional to the pressure of the steam, and consequently, the temperature of the coil. The problem then resolves itself to a method of heating the bath in such a manner that the temperature of all metal surfaces in contact with the suspension is always below the point of deposition of $Ca(OH)_2$. The rate of deposition at 5 psi (approximately 109°C) being 1.15 $g/ft^2/hr$ substantiated earlier qualitative tests indicating that deposition begins at approximately 2 psi or approximately 103°C. The temperature of any heated body exposed to the influence of the $Ca(OH)_2$ suspension must, therefore, be below 102°C. To test the practicality of such a system, a bath was operated for 12 hours in which the steam was delivered to the tank through a ¼" tubing attached to the side, near the bottom of the tank. In this particular case, the flanged copper tube was soldered to a blocked-tin lime container. Steam was admitted from the boiler at 5 psi. Stock minus 325 mesh $Ca(OH)_2$ suspension in which the solid $Ca(OH)_2$ had a specific surface of 44, 988 cm^2/g was steamed intermittently for 12 hours. At the end of this period, the $Ca(OH)_2$ in the suspension was found to have a specific surface of 44,988 cm^2/g, which was identical with the untreated suspension. No residue was found on the 325 mesh sieve. Because there was no change in the specific surface and no residue was developed for the 325 mesh sieve, it appears that heating the bath with live steam is one method by which the deposition of crystallized $Ca(OH)^2$ can be overcome. An examination of the copper pipe and tank, when the suspension had been removed, indicated a small amount of crystal growth on the inside of the tank at the point where the flanged tube was soldered to the tank. The presence of these crystals indicated that the temperature of the steam had been conducted to the flanged pipe at a sufficient temperature level to start crystal growth at this one point. It is obvious, therefore, that provision must be made for a suitable steam connection to prevent conductance of steam temperature to the walls of the tank.

Figure 9—Crystalline $Ca(OH)_2$ produced on electric coil intermittently for 24 hours. Approximately 500X. * * * * * * *

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A tabulation for the rate of growth and the specific surfaces of the $Ca(OH)_2$ suspensions for these tests are shown in Table 1.

Rate of Crystal Growth of Calcium Hydroxide and Specific Surface of $Ca(OH)_2$ in Suspension

Deposition on heated stainless steel coil at 5 psi (109°C), 10 psi(115°C) and 15 psi (121°C) steam pressure and on electric heating element

Type of Heating	Steam Pressure psi	Duration of Test hr.	Weight of Crystals Produced in Suspension 200 mesh g	Weight of Crystals Produced in Suspension 325 mesh g	Weight of Crystals Produced on Coil g	Growth Rate $g/ft^2/hr.$	Specific Surface $Ca(OH)_2$ Suspension Original Stock Suspension	Specific Surface $Ca(OH)_2$ Suspension Suspension After Test	Specific Surface $Ca(OH)_2$ Suspension Suspension Passing 325 mesh
Steam	5	continuous 12	1.12	0.18	1.78	1.15	44,988	45,078	------
Steam	5	23	----	3.85	3.55	1.44	45,078	------	46,300
Steam	10	24	----	4.35	17.63	4.09	44,988	49,368	49,750
Steam	15	24	14.44	4.63	5.22	4.52	48,303	48,941	53,594
Steam	10	24	14.57	4.66	7.18	4.92	44,070	49,083	54,699
Electric	--	24	----	7.70	12.33	7.65	44,988	48,981	48,737
Steam	Live Steam	12	0	0	----	----	44,988	44,988	------

Table 1. * * * * * *

Optical studies of the crystallized $Ca(OH)_2$ produced in commercial practice are shown in Figure 10 and Figure 11.

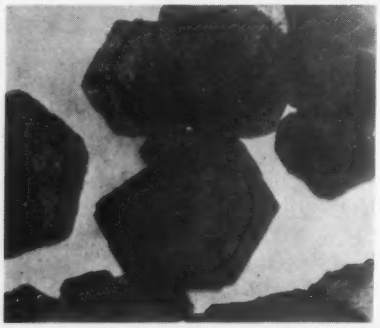

Figure 10—Crystalline $Ca(OH)_2$ produced in commercial mill. Approximately 250X. * * *

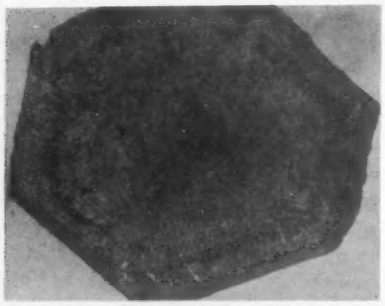

Figure 11—Crystalline $Ca(OH)_2$ produced in a commercial mill. Approximately 500X. * *

A chemical analysis of crystals deposited on a stainless steel coil is shown in Table 2, substantiating the optical identification of $Ca(OH)_2$.

Table 2

Chemical Analysis of Crystalline $Ca(OH)_2$ Deposited on a Heating Coil

Oxide Analysis	
Silica & Insoluble (SiO_2 & Insol.)	0.26%
Iron & Aluminum Oxides (R_2O_3)	0.10
Calcium Oxide	72.92
Sulphur Trioxide	0.05
Ignition Loss	26.62
Carbon Dioxide	3.50
Excess H_2O (110°C)	0.10
Compound Composition	
Silica & Insoluble (SiO_2 & Insol.)	0.26%
Iron & Aluminum Oxides (R_2O_3)	0.10
Calcium Hydroxide ($Ca(OH)_2$)	90.46
Calcium Carbonate ($CaCO_3$)	7.96
Calcium Sulphate ($CaSO_4$)	0.09
Excess H_2O (110°C)	0.10
H_2O of Crystallization (calculated)	1.04

The inclusion of crystals of $Ca(OH)_2$ in the surface of drawn steel bars is shown in Figure 12, Figure 13 and Figure 14.

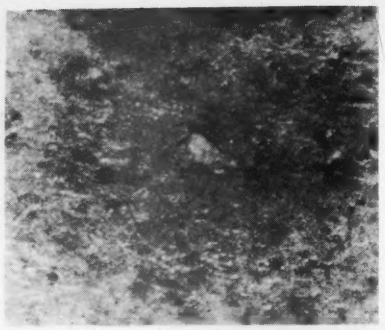

Figure 12—Crystal of $Ca(OH)_2$ imbedded in steel bar. Approximately 175X. * * * * *

Figure 13—Crystal of $Ca(OH)_2$ imbedded in bar. Approximately 500X.

Figure 14—Very small crystals of $Ca(OH)_2$ imbedded in steel bar. Approximately 175X. * *

The effect of surface abrasion on a drawn steel bar by crystals of $Ca(OH)_2$ is illustrated in Figure 15.

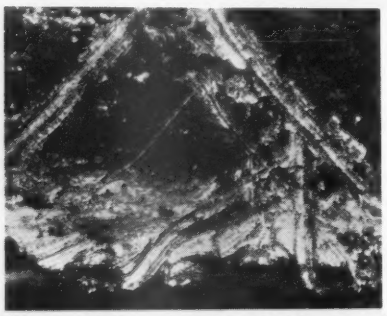

Figure 15—Effect of crystal abrasion of steel surface during drawing. Approximately 500X.

Discussion

It has been shown in this investigation that crystalline $Ca(OH)_2$ can be produced upon heated bodies submerged in suspensions of $Ca(OH)_2$. Though the accuracy of these tests has not been sufficient to definitely establish the temperature at which crystals begin to form, experimental proof has shown that crystallization begins at approximately 103°C. Any heated body submerged in $Ca(OH)_2$ suspensions at this temperature or above will deposit crystallized $Ca(OH)_2$. It has also been shown that the rate of deposition is proportional to the temperature of the heated body up to 15 psi or approximately 121°C. There is no doubt that this same phenomenon will occur under similar conditions in commercial dipping baths. It is further postulated that in the presence of large quantities of plastic solid $Ca(OH)_2$ small crystals of $Ca(OH)_2$ can become the nucleus about which amorphous $Ca(OH)_2$ can become attached to form spheres composed chiefly of the amorphous material. It has been further shown that live steam admitted to the $Ca(OH)_2$ suspension will maintain bath temperatures below 100°C where any heat above 100°C will be dissipated by the large volume of water in the bath at atmospheric pressure. This method of heating avoids any possibility of crystallizing $Ca(OH)_2$ precluding formation of spheres of amorphous $Ca(OH)_2$ with crystalline $Ca(OH)_2$ as the nucleus.

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Commercially, this phenomenon has been found in every wire mill using steam heating coils. Both crystals and spheres of amorphous $Ca(OH)_2$ have been identified. In commercial practice, the rate of deposition of crystals has been so high that all the $Ca(OH)_2$ has been converted to platy crystalline $Ca(OH)_2$. Under these conditions very little or no spherical amorphous form was present, undoubtedly because of the small amounts of amorphous $Ca(OH)_2$ remaining in the bath. Two or three commercial systems have been installed using live steam. After several months operation, little or no evidence of crystalline $Ca(OH)_2$ has been reported.

(*Please turn to page* 1297)

Tin-Zinc Alloy Plating; Its Application to Copper Wire

by Frederick A. Lowenheim
Supervisor, Electrochemical Research
and
Robert T. Gore
Technical Service Engineer
Metal and Thermit Corporation
Rahway, New Jersey

This paper is an effort to acquaint the wire industry with an interesting and valuable new coating which has amply proved its worth in other fields. Although it has not yet been applied to copper wire on a commercial scale, many of the properties of the tin-zinc alloy deposit suggest that it would offer several advantages in such an application. The basic process is well established and as far as equipment is concerned adaptable to any set-up designed for alkaline tin plating: specific reference may be made to the process and machine described by **Lowenheim** and **Bruestle** three years ago (1).

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Preliminary work has indicated that no unusual problems need be anticipated in adapting the tin-zinc plating process to moderately high-speed continuous plating of copper wire. The putative advantages to be gained by the use of the tin-zinc alloy coating, as compared with pure tin, include improved solderability and far less susceptibility to the low-temperature phase-change known as gray tin or "tin pest." The latter phenomenon has been known for a long time, but has become a source of concern only fairly recently with the interest, both military and civilian, in operation of equipment under conditions encountered in the far north, at high altitudes, or in freezers.

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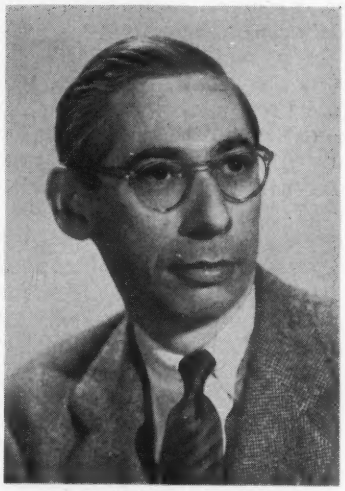
The codeposition of tin and zinc has been the subject of several publications dating as far back as 1915 but the first commercial process was announced by the Tin Research Institute of England in 1948 (2). The plating bath which they developed was characterized by good stability, operability and tolerance for plant conditions, and thus ranked as the first successful attempt to codeposit these two metals on a commercial scale, previous work having been of a "beaker" nature.



Dr. Frederick A. Lowenheim

Dr. Lowenheim graduated from Columbia University in 1930 with an A.B. degree and secured his Ph. D. in 1934. He joined Metal and Thermit in 1936, where he is now Supervisor of Electrochemical Research. His work is concerned principally with tin and tin alloy deposition on which he has secured many patents. He is also an author and has contributed to a number of technical handbooks.

Mr. Gore is a graduate of Pennsylvania State University, 1934, where he received a degree of B.S. in Electrochemical Engineering. He followed this with two years of graduate study and teaching at the University of Pennsylvania. Since 1951 he has been with Metal and Thermit in charge of Technical Service in the field of electroplating.

These two men collaborated in the preparation of this paper for presentation before The Wire Association at its Annual Convention in Chicago, November 14-17, 1955.

★ ★ ★

Tin and zinc can be codeposited in practically any desired proportions, and after careful study of the system and of the properties of various electrodeposited alloys, the TRI authors came to the conclusion that the composition 80% tin, 20% zinc possessed the best combination of desirable properties, including solderability, corrosion resistance and operability of the bath. This recommendation was later modified somewhat to 75/25 tin/zinc. Fortunately the exact composition is far from critical; the properties of the deposit vary only slightly as the composition changes, and a tolerance of 7 to 10% either way can be granted. This feature is important because the exact control of an alloy plating process may be very difficult, but if only approximate control is required the problems are greatly simplified.

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Nevertheless it must always be admitted that the codeposition of two or more metals demands somewhat more analytical control than the plating of a single metal, although in favorable cases the extra effort may be slight. For this

reason it is necessary to justify this effort from a pracical viewpoint, and to answer the question: why is the alloy deposit better than the individual metals? In the present case this question takes the form: why is tin-zinc better than tin alone? The answers to this question are three points of superiority: (1) corrosion resistance, (2) retention of solderability, and (3) resistance to the spread of the low-temperature phase transformation known as "tin pest." As far as copper wire is concerned, (2) and (3) are probably of greater interest than (1), but all are worthy of consideration. In addition, tin-zinc is the equal of tin in solderability when freshly plated, and is equally "producible"—that is, the operations involved in plating it are no more complicated or difficult, barring one or two additional analytical determinations. The three points may be discussed in order.

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(1) Corrosion resistance. Although the copper wire industry is not directly interested in the corrosion performance of coatings on steel, it may be mentioned that extensive tests, including salt spray and outdoor exposure in both marine and industrial environments, have indicated the good corrosion resistance of the 75/25 tin/zinc alloy. It is far superior to pure tin in protecting the underlying steel against corrosion.

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Of more immediate interest are some comparative tests of tin vs. tin-zinc on copper, exposed for two years to a severe marine environment. Copper panels, electroplated with .00035" tin, were completely covered with corrosion product in two months, and at the end of one year the surface had turned greenish, indicating corrosion of the underlying copper. Similar panels plated with the same thickness of tin-zinc had only slight corrosion product at the end of a year, and only after two years did they begin to turn slightly green.

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In the wire industry acceptability of the tin coating is measured by the polysulfide dip test. Electroplated coatings of tin on copper wire, in order to pass two dips in this standard cycle, must be about 15 millionths of an inch thick. Tin-zinc coatings of comparable thickness easily passed the test also.

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(2) Solderability. Unfortunately there is little agreement as to what constitutes good solderability. This situation is due partly to the fact that there is no generally accepted test for the property, partly to the differing methods of soldering in various industries. A material which may solder rapidly and efficiently under one set of manufacturing conditions may not be so well adapted to a different production technique. To cite only two examples out of many, the can-manufacturing industry will have different requirements from those of the electronics industry. Further, the exact composition of the solder used, and the necessity, or lack of necessity, of using non-corrosive fluxes, enter the picture. Most will agree, however, that at a minimum a surface to have good solderability must be easily wet by the solder used, and most tests of solderability are in effect tests of the wettability of the surface. Many tests are in use, involving the measurement of capillary rise of solder along a twist of wire; the spread of a pellet of solder on a flat panel the appearance of a wire, twisted according to a definite technique, after dipping in a pool of molten solder; etc. It is no part of this paper to discuss the relative merits of these tests; in fact each of them appears adequate for the purposes of those who use them.

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In spite of the confused situation pictured, however, some generalizations seem to have validity, and certainly almost everyone would agree that tin is easy to solder and zinc and aluminum very difficult. Electroplated coatings usually given consideration when solderability is desired have been tin, tin-lead, cadmium, and silver.

Surprisingly enough, considering that zinc is a major constituent, the tin-zinc alloy proves to possess outstanding solderability, whether measured by one of the standard tests or by actual performance in production. When freshly-plated tin-zinc is compared with freshly-plated tin, little or no difference is observed. It is well known, however, that the solderability of tinned surfaces deteriorates more or less rapidly, depending on conditions of storage; the same is true of most of the other coatings normally used. An outstanding property of tin-zinc coatings is the absence of this deterioration: parts plated with this alloy retain their excellent solderability almost indefinitely under normal conditions of storage, as far as can be measured by any of the accepted tests. (Naturally the word "indefinitely" must be interpreted reasonably: the coating has been in widespread commercial use only a few years. Some of the earliest samples are still solderable at this writing; retention of solderability even for a year is considered excellent performance.)

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The importance of this stability in storage varies with the proposed application; obviously it permits stockpiling and inventory of parts and removes the necessity for careful scheduling of assembly operations to follow promptly after plating, or of reactivating treatments to revive the solderability of aged parts. This can be of particular importance in the small lead-ins, terminals and similar types of parts where copper wire is concerned.

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It is, unfortunately, not possible to quote quantitative results which would illustrate or corroborate the above statements. Most accepted tests of solderability do not yield numerical data, but qualitative descriptions such as "excellent," "fair," etc. based often on mere visual inspection. It is hoped that future work, such as that being conducted in committees of RETMA and ASTM, will improve this situation.

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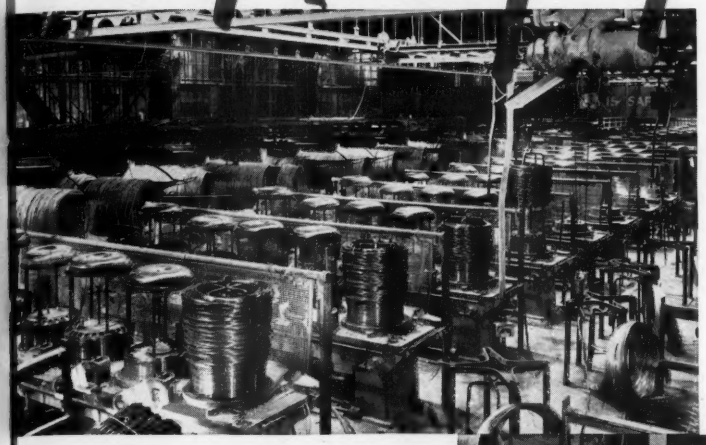

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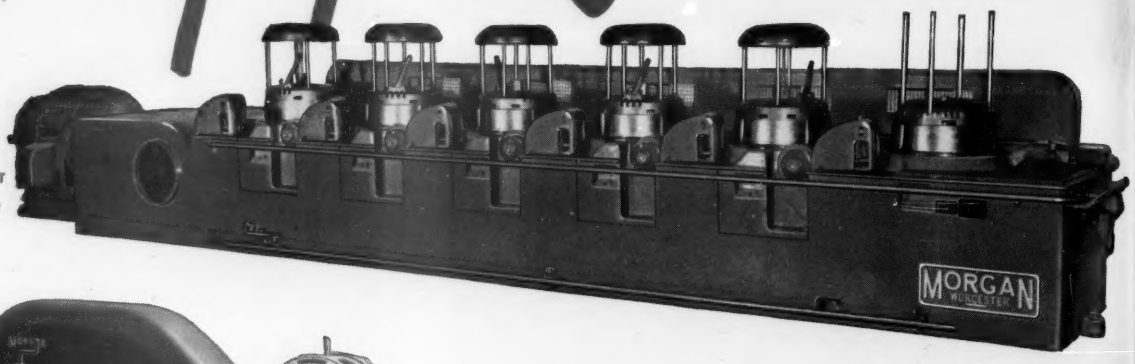

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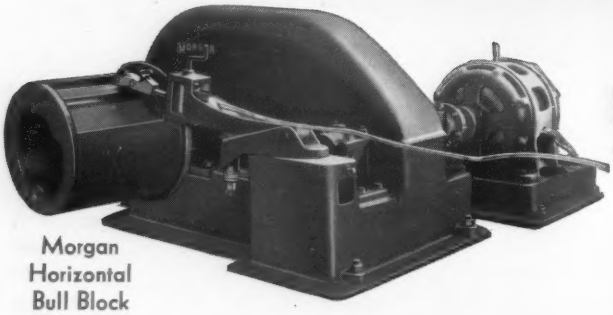

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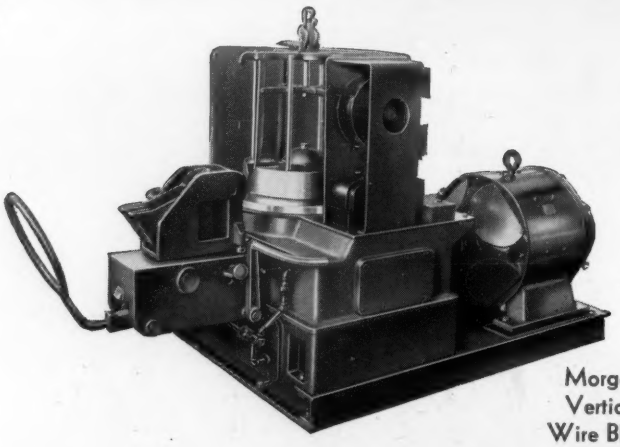

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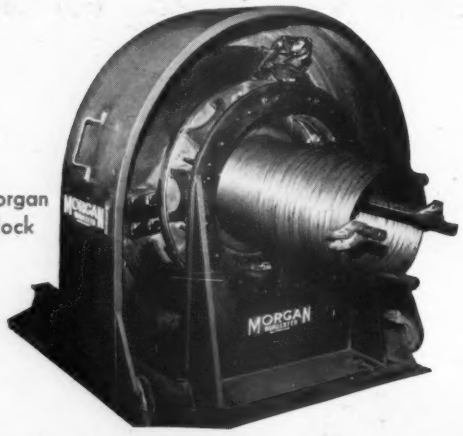

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(3) "Tin Pest." Tin can undergo a phase transformation at low temperatures, changing from the familiar white, ductile, metallic material to a gray, brittle, nonmetallic modification. This phase change, from ordinary beta or white, tetragonal tin to gray, alpha or cubic tin, also involves a decrease in density from 7.28 to 5.75 and a corresponding increase in volume. Since the gray tin is also brittle, the volume change causes crumbling and disintegration of tin castings and flaking off from the basis metal of tin coatings. The equilibrium temperature at which white or ordinary tin changes into gray tin is 13° C or 55° F—in other words tin is thermodynamically unstable on a cool spring day. Fortunately the change is almost immeasurably slow at all temperatures normally encountered in temperate climates, and even a cold winter practically never causes the phase transformation to proceed with significant speed. However, the velocity of the transformation increases as the temperature is lowered down to about -40°, below which it begins to slow down again. This phase change has been of little or no concern to tin users until recently—as evidenced by the fact that although tin has been in widespread use since Biblical times the phenomenon itself was only discovered and characterized less than one hundred years ago. At the present time tin retains its classical usefulness, and the only circumstances which render the phase transformation a potential or actual source of trouble are those in which components are expected to function under conditions of extreme and continuous cold: the arctic zones, extreme high altitude, and possibly in low-temperature equipment such as freezers. It has thus been of interest to the Canadian and our own Armed Services, and the most recent and complete investigations have been undertaken by or for these agencies.

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The findings of a research group at Stevens Institute of Technology, under contract from U. S. Army Signal Corps, can be summarized as follows: pure electrodeposited tin transformed in about 4 days in a cold cabinet at -100°F, whether inoculated* or not.

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On the other hand panels plated with tin-zinc not inoculated showed no transformation in 2 years of cold storage, and even when inoculated required at least seven months for some evidence of transformation.

★ ★ ★

In our own less exhaustive tests, we have found tin coatings to transform in three or four days at dry-ice temperatures, whereas tin-zinc began to show slight evidence of the change after six months; and furthermore, while the rate of spread of the "disease" on tin was very high, the small spots of infection hardly spread at all on tin-zinc, remaining mere isolated spots, so that even though there was some transformation, the practical usefulness of the tin-zinc plating was not destroyed. Figure 1 shows the appearance of the tin-plated copper panels after only four days at dry-ice temperatures; the panel at the left shows the method of inoculation by Scotch-taping some gray tin tightly to the panel; the one at the right was not inoculated. The small piles of powder are bits of gray tin which fell off the basis metal when it was disturbed. By contrast, Figure 2 shows three tin-zinc plated copper panels after six months at dry-ice temperature: the two on the left were inoculated, the third was not. Although the small dark spots are probably indications of phase transformation, no peeling or

(*Please turn to page* 1295)

(* It should be explained that the transformation or "disease" spreads from points of "infection" or inoculation with gray tin. The transformation can thus be speeded by infecting a panel with some gray tin, and once started tends to spread like a sort of skin disease—hence the popular name tin pest or disease.)

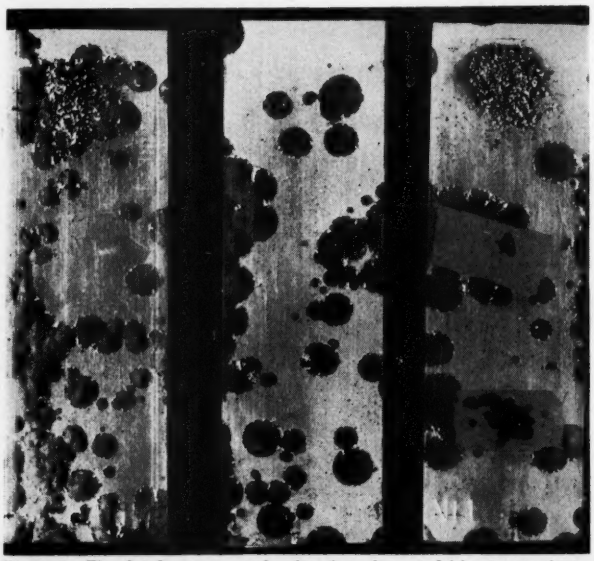

Figure 1. Tin-plated copper panels after four days at dri-ice temperature. Left and middle: inoculated with gray tin; right: not inoculated. Dark patches show where tin has flaked off; piles of material on bottom were scraped up from bottom of envelope which protected the panels during test.

Figure 2. Tin-zinc plated copper panels after six months at dry-ice temperature. Left and middle: inoculated; right: not inoculated. Dark areas under tape are inoculant. Grayish streaks are finger-marks and should be disregarded. Only evidence of gray tin is small dark spots on left and middle panels.

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Wax Lubricants in Non-Ferrous Wire Drawing

by John Werner, Field Engineer
Industrial Products Department
S. C. Johnson & Son, Inc.
Racine, Wisconsin

The need for a more efficient lubricant in the wire drawing industry has prompted many concerns to use wax with its exceptional lubricating qualities as a new way of obtaining greater wire production and better finishes.

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Any discussion of wax or waxes and their uses must begin with an attempt to establish common ground for the meaning of the word wax. So many materials have been called wax that an accurate definition has become almost impossible. For simplification it can be said that all waxes, regardless of their source, have the following properties in common:

1. They are solid at room temperature.
2. They exhibit adhesive properties toward surfaces to which they are applied.
3. They are cohesive in that they adhere to themselves in cold molding.
4. They are plastic solids having plastic flow.
5. They are essentially insoluble in water but soluble in organic solvents.
6. They are capable of being buffed to a polish.

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The biggest problem encountered by science has been to put the proper waxes into a stable form so that they are usable.

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All of us are familiar with waxes in one form or another. Our first contact was probably with paraffin in candles. Then there were wax seals of paraffin on jelly jars. We also remember wax car polishes that were so difficult to apply. The use of bee's wax in the tool rooms where high finish grinding operations are performed may be familiar.

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These waxes are only a small percentage of the total number of waxes known and cataloged according to their type and usage characteristics. Actually over 1700 different waxes have been identified. Of this number only a few are outstanding in their lubrication values. That is, in their ability to withstand high temperatures, to resist high pressures and to exhibit a polar characteristic.

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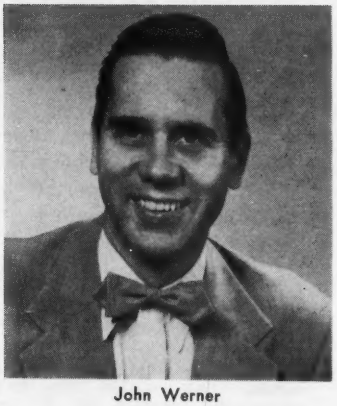
The first use of wax in a metal working lubricant was prompted by a desire to utilize these three outstanding characteristics. Let us review them: lubricity at high temperature, lubricity at extremely high pressures and polarity. A wax blend having these three characteristics was discovered during a research program conducted by the University of Michigan in conjunction with the Johnson Wax Laboratory.



John Werner

Prior to joining his present company, Mr. Werner was Senior Process Engineer at the A. C. Spark Plug Division of General Motors Corporation. He studied mechanical engineering at Marquette University and had worked in various production capacities with Allis-Chalmers Company before joining General Motors. This paper was prepared for delivery at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955.

One item of information discovered by this study was worth the entire effort. That is, specific wax ingredients which are not useful individually can be combined to form a base that provides the properties necessary for high pressure and high temperature lubrication. Each of these dissimilar materials augment the value of the other so that in combination their value is far greater than the sum of their respective values. Let us examine the following facts:

1. **200,000 pound pressure resistance. Wax will withstand 200,000 pounds per square inch and still supply fluid lubrication. This is not for an instant in the laboratory but on actual stainless steel wire drawing. A one ton coil of stainless steel wire was coated with a wax emulsion and allowed to dry. This ⅜-inch diameter wire was then reduced to 5/16 diameter in one pass through a single die. The tensile strength of the material was 218,000 pounds per square inch. It is known that the compressive strength of a material is always higher than its tensile strength. It is known, too, that the pressures involved in the drawing die are much higher than either the compressive or tensile strength of the wire being drawn.**
   After drawing, the film of wax left on the wire was measured and found to be .0004 of a milligram per square inch of surface or about one molecule thick. The surface finish of the wire was bright and scratch free indicating a fluid film was preserved between the die and the wire at all times. The fact that a continuous film of wax remained on the wire for its entire length after drawing proved definitely that the wax had withstood the pressures involved and had resisted the high temperatures generated.
2. **A temperature tolerance of 450° F. That is, wax has a high lubricating value even at temperatures where ordinary lubricants fail or supply inadequate fluid films. Again, this 450° temperature tolerance was not discovered to be true for only an instant in the laboratory, but it was proven true under actual operating conditions. Experiments in forming hot magnesium in aircraft work showed**

wax lubrication to be efficient at 600° F. where all other fluid film lubricants failed. This wax emulsion, similar to that used in wire drawing, was sprayed on the hot magnesium plate. The piece was immediately placed into the press and formed. It is known most of our waxes volatilize at 468° but enough lubrication was still supplied by the wax to do the job. This type of work is still being done successfully in the aircraft industry.

3. Polarity. Here is something that is desirable in any lubricant. It is the ability of the lubricant to fasten itself tenaciously to the metal part it is lubricating. But what exactly is polar attraction? How does it work? The phenomenon of polar adsorption has gained acceptance in scientific literature. Consider the atoms which make up the metallic solid of the die or piece to be worked. When the atoms of the metal crystallize into a solid mass they are joined together as a result of the attraction they have for one another.
Electrical charges constitute the attractive forces of those atoms within the interior of the metallic mass. The interior atoms are all balanced by the attractive forces of the atoms that surround them. However the surface atoms do not have atoms beyond them and the unsatisfied electrical charges of the surface atoms, tiny though they may be, all combine to form a field of influence at the metallic surface. This influence is electrical in nature.
Such a field is capable of attracting certain other substances. This attraction is called polar adsorption. The metal surface serves as the adsorbant holding the adsorbate on its surface. If the metal surface is to strongly exercise this quality of polar adsorption upon the adsorbate it is necessary that the adsorbate also possesses similar characteristics of attraction or polarity. In wire drawing it is necessary that the active agents of the lubricants possess polarity.

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The waxes used in metal working lubricants possess this quality of polar attraction. Whether or not the material is wax is not the sole criterion. Its chemical structure will be the determining factor in accepting or discarding it for use as a lubricant. The word wax carries the same value here as does the word "wood" to the furniture builder or the word "metal" to the automobile manufacturer. At best it describes a broad class of materials. Now, what has this to do with wire drawing? First, let it be said that we as suppliers are new in the wire drawing industry. A great deal has been learned about the problems involved, and yet there is much more to be learned. The variables are endless concerning dies, speeds, reductions, slips, wire metallurgy, and many many more. Wax emulsions and dispersions are not a panacea but they do possess exciting possibilities. After experimenting with wax and its characteristics, we have found that wax in many ways surpasses anything yet seen as a wire drawing lubricant.

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What can be expected from wax emulsions in drawing copper wire? The following facts were learned over a two year test period by people in the wire drawing industry who tried wax lubricants.

1. All sizes of wire are drawn at a 20 to 1 dilution.
2. There are no insoluble copper soap formations.
3. There are no heat input requirements. The solution runs most effectively between 85° F. and 95° F.
4. The pH of the solution is stable; there is no gradual drop-off in pH. The pH of the material runs between 8.5 and 9.5.
5. There is no mixing procedure required as the emulsion lets out easily in cold water without agitation or heating.
6. There is no warm-up period in running either the heavy or the fine wire. Full reels can be run immediately upon starting the machine.
7. There are no cleaning requirements for the finished wire. Any wax left on the wire will volatilize off at 468° F. without leaving a carbonaceous residue.
8. The dilution check of the material is simply one of breaking the emulsion with an acid salt such as sodium sulphate.
9. There is no evidence of sticky capstans in the fine wire drawing; the machine runs extremely clean.
10. Sufficient lubrication is supplied at 20 to 1 to take care of the percentage of slip between capstans.
11. There is no foaming with the wax emulsion at any time.
12. Wire temperatures run between 10° and 15° F. lower after drawing with the Wax Drawing Lubricant.
13. Power requirements are reduced 10 to 15 per cent.

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It might be pointed out here that the 13 foregoing points were not arrived at in the laboratory experiments but were reported from actual production runs by some of the larger wire drawing firms. Die life, an indefinable value at best, has been reported as equal, as good as, better than and lower than that experienced with conventional lubricants. It was found that die life has been measured in minutes of running time, pounds of wire per die and cost of die per 100 pounds of wire. The ways of determining die life are numerous and there are many more that have not been mentioned. All the methods have certain points in their favor. The concern with die life is of great importance; however, the role of the lubricant is only one of the variables that must be taken into account.

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Aluminum wire presents another phase of lubrication in which waxes havs been used to an advantage. At present a wax dispersion in oil is being used successfully. At this writing plans are underway to test a water emulsion wax on aluminum wire drawing but as yet no data is available.

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In drawing aluminum wire of the various alloys such as electrical conductor, alclads, 56S, etc., it has been found in actual production that a wax in oil dispersion diluted with plain mineral oil of 500 second viscosity or lighter has given excellent results. The dilution is usually eight parts of oil to one part of wax concentrate. This mixture draws all sizes of wire from ⅜ diameter rod down to fine screen wire. Wire has been drawn in all sizes with the viscosity of the mix 150 seconds at 100° F. and has yielded a bright scratch free wire surface.

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As this material is a dispersion of solid waxes in mineral oil, with a partical size of one micron or less, the oil used should not be less than 150 seconds SSU. Experience has also shown that the temperature of the entire mass of lubricant should not exceed 120° F. as this will melt the solid waxes causing them to go into solution. In this stage they are not as efficient as they are in the first stage, although the melting process does not effect the dispersion. The dispersion will reform upon cool-

ing. People in the industry who are now using wax have heat exchangers on their central systems and find that temperature control is not critical. It is as easy to maintain 85 to 95° F. as it was to maintain 110 to120° F.

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The following data was received from users of this wax dispersion in oil. It is simply a statement of what has happened when wax was used as an aluminum wire drawing lubricant:

1. **No mixing procedure required. Simply let out the dispersion concentrate in the oil chosen and the material is ready for use.**
2. **No heat requirements. The wire runs more efficiently with a cool solution than with a hot one.**
3. **All alloys and all sizes of wire drawn with the same dilution.**
4. **Brighter wire.**
5. **Wire is protected from tarnish by a single molecule thick wax coating after drawing.**
6. **Cooler wire temperatures because frictional heat has been reduced.**
7. **Higher speeds in wire drawing because of superior lubrication.**
8. **Lower power requirements; savings ranging up to 10%.**
9. **Faster settling of fines due to lighter viscosity of material.**
10. **No stain in annealing or heat treating.**
11. **Makes possible greater reductions without annealing stages.**
12. **Maintains and increases die life.**
13. **Tensile strength of the wire has been increased 15 to 20% with the use of wax in some cases.**
14. **Power requirements dropped off 10 to 15% as compared to other lubrication.**

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We have found in the drawing of aluminum wire that die life has been variable. As was said before, the life of a die is unpredictable, therefore it would be impossible to make any definite claims. Only a closely watched program over a period of many months could be used as a guide to increase or decrease in die life. As yet we have been unable to find a way to check and control the variables in the life of the die.

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When wire is drawn with a wax lubricant, a very thin continuous film of wax is left on the finished drawn wire. This coating of wax protects both copper and aluminum wire from corrosion. As is known, waxes are fairly good corrosion inhibitors and they will protect and maintain a bright surface on wire, under normal conditions, longer than oils. In many instances the waxes that are on the finished drawn wire are removed completely in subsequent annealing. The waxes remaining after wire drawing volitalize at 468° F. without a carbanaceous residue. If there were no annealing operation and it became necessary to clean the wire, the waxes could be readily removed by hot emulsifing or alkaline cleaners such as produced by commercial cleaning material producers.

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The only requirement in cleaning waxes from any metal surface is that the temperature of the solution be kept at 180° F. or hotter so as to completely melt any waxes on the surface of the metal. They can then be readily emulsified or washed off by the cleaning fluid. If vapor degreasing is the method of cleaning, the temperature will be higher than 180° and the waxes will be completely removed.

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Fundamentally all wire drawing lubricants perform two functions. First, they are required to lubricate the die-wire interface to facilitate the passage of the wire through the die. Second, they must disperse the heat that is generated both by friction and the deformation of the metal. If a wire drawing lubricant can do these two things better it is obviously a more desirable wire drawing lubricant to use.

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These specially blended waxes have proven their ability to lubricate better. It has been proven in the field and in the laboratory that they disperse heat more rapidly. But, what basis in fact do we have for making the above claims?

1. **Wire temperatures have run, by actual surface thermocouple measurements, 10 to 15° F. lower as compared with conventional lubricants. Laboratory calormeter tests have also shown that wax emulsions and dispersions have a higher cooling value than soap fat emulsions and lard-tallow-mineral oil mixtures.**
2. **In the field wire drawing machines have increased their speeds. They have run at faster surface feet per minute without any change except the addition of wax to the lubricant being used. One machine increased from 5,000 to 5,500 surface feet per minute. Another from 2,400 to 2,700 surface feet per minute.**

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Obviously the frictional drag, having been reduced by better lubrication of the wire through the die, allowed the D. C. Motor to pick up speed because of the reduced load. Here again are the three reasons why wax blends do a better lubrication job.

1. **They resist pressures as high as 200,000 pounds per square inch.**
2. **They resist temperatures of 450°F.**
3. **They have an inherent polar attraction to metals.**

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Any lubricating material incorporating all three of these vital properties can be of service to the wire drawing industry of today. Wire drawing equipment builders are constantly striving for higher speeds and metallurgists are developing better and tougher alloys. The emphasis is on higher production at lower cost. An important contribution to this highly exacting science is being made with wax lubricants. Anything that can be done to improve lubrication is a real contribution. Anything that can be done to decrease heat is of vital importance. Heat is the primary destroyer of die life and heat is the primary deterrent to increased speeds.

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Perhaps it can be best summed up in saying coolness provides success, heat causes failure.

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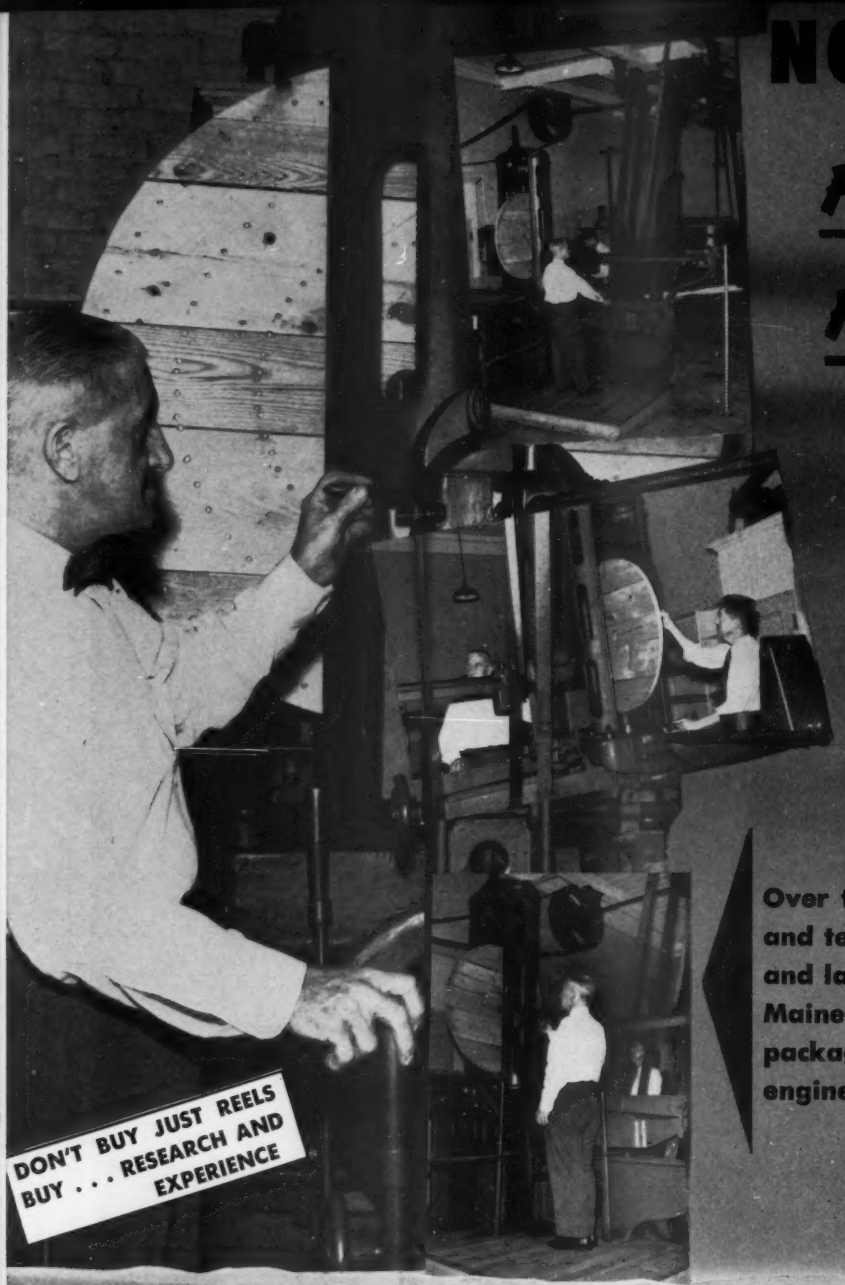

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Chrome Carbide for Hot Extrusion of Brass and Copper

by A. Earle Glen
Manager—Die Sales
Carboloy Department of General Electric Company
Detroit, Michigan

During the past twenty-five years we have witnessed complete acceptance of cemented tungsten carbide as a draw die material. Once the tremendous advantage of using carbide was demonstrated, we saw a rather rapid conversion to hard-metal dies in the wire and tube mills.

★ ★ ★

In the processing of copper and brass tube and rod, the hot extrusion process plays an important role. There have been several attempts in the past to apply tungsten carbide base materials to hot extrusion. These attempts have not been successful because of two basic reasons.

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One is that tungsten carbide base materials oxidize at temperatures required for the hot extrusion of copper and brass. The second reason is that the coefficient of expansion of tungsten carbide is about one-half that of steel. This means that at operating temperatures the die insert loses much of its support and breaks under the extrusion pressure.

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The development of chrome-carbide provided a material which has very good oxidation resistance and hot hardness which made it a suitable candidate for hot extrusion applications.

What is Chrome Carbide?

CHEMICAL COMPOSITION

83% Cr3 C2
2% W.C.
15% Ni

A. Earle Glen

This paper was prepared for delivery at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955. In this paper the author describes a pertinent application of one of the newer additions to the growing family of carbides.

Arthur Earle Glen was born in Ottawa, Canada in 1907. He joined the Cleveland Wire Works in 1928 as a service engineer, a position he held until 1934 when he was made a die salesman. As a member of the Carboloy organization, he continued to specialize in die sales, and in 1941 was moved to the Carboloy general offices in Detroit, becoming manager of die sales in 1944. Mr. Glen is the author of many technical articles dealing with drawing and blanking dies.

What Do Some of These Properties Mean When Applied To Hot Extrusion?

I. Oxidation Resistance

Grade 608 is highly resistant to oxidation at all temperatures up to 1800°F, and favorable results have been obtained in tests conducted at temperatures over 2000°F. When exposed to a temperature of 1850° for 24 hours, the samples (Fig. 1) were only slightly discolored while simultaneously exposed samples of 18-8 stainless steel were scaled appreciably, and the tungsten carbide samples were heavily oxidized.

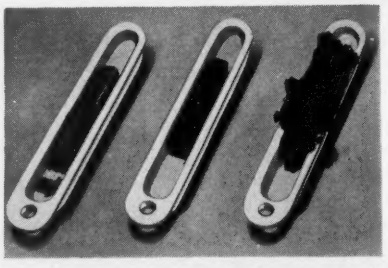

Figure 1—(Left to Right): 18-8 stainless, Grade 608 Chrome Carbide and tungsten carbide, all originally identical size and shape, after exposure in air at 1850°F for 24 hours. ★ ★ ★

PHYSICAL PROPERTIES

Hardness 88 R"A"—Equivalent 72 R"C"
Density 7.0 gm/cc
Transverse Rupture strength 100,000 psi
Abrasion resistance—Much higher than steel, not as high as tungsten carbide
Steam erosion resistance—Excellent
Coefficient of expansion—4.9 x 10^{-6} in/in °F. 68° - 248°F
5.1 x 10^{-6} 68° - 427°F
5.3 x 10^{-6} 68° - 608°F
6.1 x 10^{-6} 300° - 1800°F
Corrosion resistance—very good.
Electrical conductivity—2.2% of copper at 20° C.
Electrical resistivity—80 microhms/cm/cm^2 at 20° C.
Magnetic properties—Non-magnetic
Oxidation resistance—A-excellent up to 1800°F.
B-favorable even beyond 2000°F.

II. Coefficient of expansion

MATERIAL		
Grade 44A (W.C.)	2.80 x 10^{-6} in/in/°F	from 70° - 1292°
Grade 608	6.1 x 10^{-6}	from 300° - 1800°
SAE 1095 steel - Heat Treated	8.20 x 10^{-6}	from 70° - 1292°
H.S.S. 18-4-1 heat treated steel	7.10 x 10^{-6}	from 70° - 1292°

Microstructure

The microstructure of Grade 608 Chrome Carbide is unlike that of other cemented carbide materials. (Fig. 2) The structure consists of essentially two phases—the chromium carbide grains, and the matrix which is solid solution phase consisting of chromium carbide and nickel.

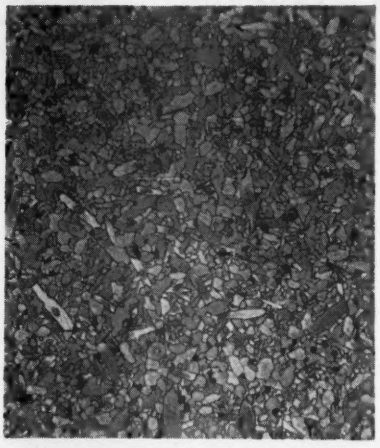

Figure 2—The microstructure of Grade 608 Carboloy Chrome Carbide magnified 500 times.

How is This Material Applied To The Application of Hot Extrusion?

Basically the procedure is the same as applied to wire drawing dies, of which you are all familiar. A Chrome Carbide nib is supported in a steel casing. As an example Figure 3 shows a Chrome Carbide nib in the proper proportions.

★ ★ ★

You will note O.D., I.D. and height. Also, the O.D. of the nib and I.D. of case had a 1-1/2° taper on a side. This nib is then mounted in a hot work tungsten-chrome steel casing with .008 interference between the case and nib.

Finishing Techniques

Generally, techniques and equipment used for finishing tungsten carbides are adaptable to Grade 608 Chrome Carbide as well. This includes the use of diamond grinding wheels and lapping compounds and silicon carbide grinding wheels. Polishing is not necessary.

Preparation Before Using

Experience to date recommends preheating the die in an oven to 1000°F. This reduces the thermal shock when the die is put into service in the extrusion press. If this is not done, there is a tendency to get premature thermal checking on the surface of the nib and a spalling out of the chrome carbide. The die should not be quenched for cleaning or cooling.

Benefits From the Use of Chrome Carbide

One of the outstanding advantages resulting from the use of Chrome Carbide is the ability of this die material to hold size during use. This is due partly to the hot hardness of the material, which enables the die to resist erosion and wear.

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Another important characteristic is the ability of Chrome Carbide to withstand extrusion pressures which cause other die materials to upset, cave-in and close-in. To illustrate this, in one instance 200 billets were pushed through a Chrome Carbide grade 608 die without removal or cooling, with negligible change in die size. With performance such as this, it is evident that die inventory and refinishing costs are held to a minimum. With tougher alloys, and higher temperatures and pressures the advantages of Chrome Carbide stand out in greater relief.

★ ★ ★

Consistently higher quality extruded rod is possible with Chrome Carbide dies because this die material is less reactive at extrusion temperatures than conventional extrusion die materials. Grade 608 dies have exceptional resistance to pick-up, with reduced scoring of rod when compared with conventional die materials.

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To date, Chrome Carbide has been successfully used on rounds from .440 diameter to 2.157 diameter; on hexagons from .435 to 2.050. One mill in particular has produced over 50,000 billets through Chrome Carbide dies. Many of the dies have produced

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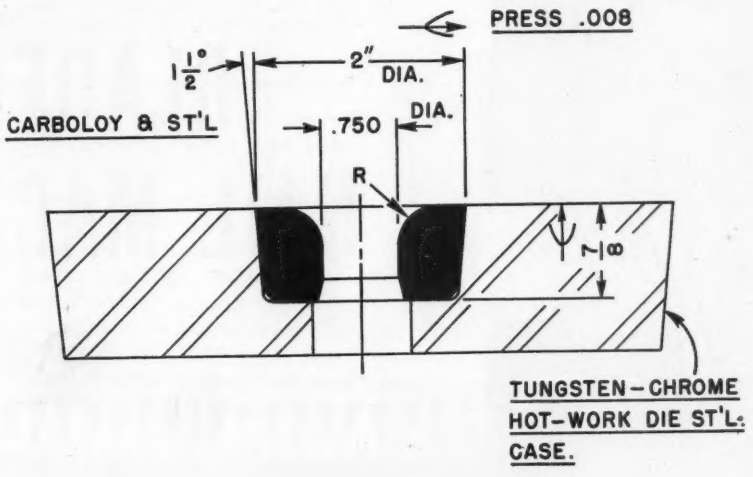
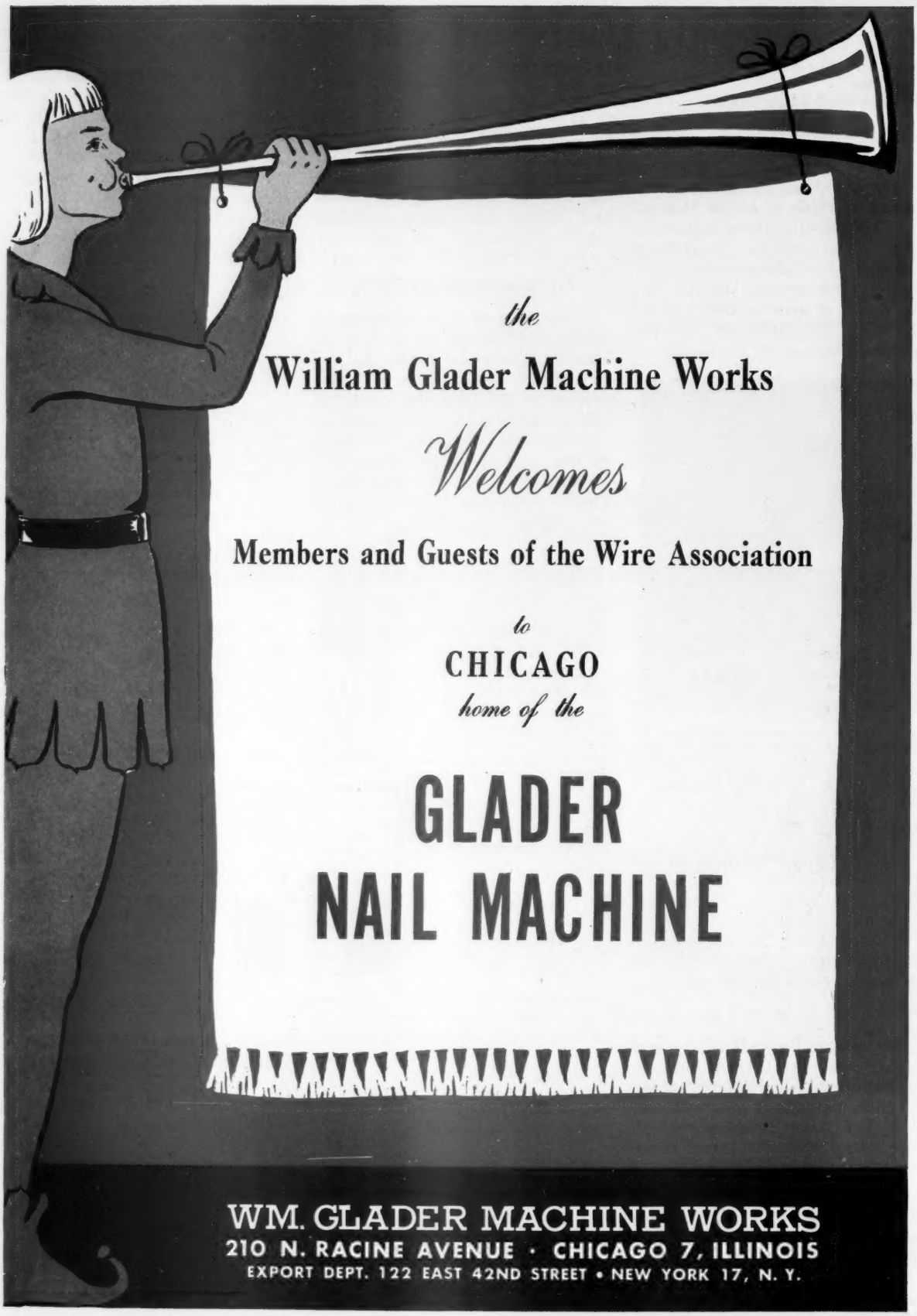


TYPICAL 608 HOT EXTRUSION DIE

Figure 3.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Wire Die Shape and Finish; Some Recent Developments in Production and Inspection

by Eric J. Schneider, Vice President
Engis Equipment Company
Chicago, Illinois

The wire die, while relatively unchanged in its general appearance and purpose, has undergone some changes over the past few years. Die materials, die finishing methods and theories on die performance have contributed to changes in thinking which have necessitated that there be provided a better group of tools to produce and devices to check.

★ ★ ★

As I assume all you gentlemen to be well familiar with American practices, I shall take the liberty of devoting much of my presentation to what I have seen in Europe over the past few years so as to give a chance to compare where important differences may lie between our own practices and the ways of our friends abroad and where we may all agree on what is proper engineering thought.

★ ★ ★

Let me deal first on the devices and methods on how to produce.

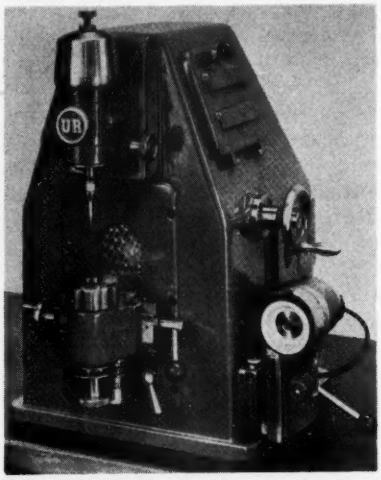


Figure 1.

Figure 1 shows a German die polishing machine primarily for tungsten carbide work which has a rather attractive arrangement and incorporates some features which I believe are a bit unusual. Mechanically the machine appears exceedingly solidly built with a large range of adjustments for die and needle position, reciprocation and speed and it is designed for dies as small as .30 millimeter. The needle grinding attachment appears particularly original because all needle regrinding is done in the chuck which holds the needle when it polishes. This insures perfect centering of needle and unusually effective control of the entire finished operation.

Eric J. Schneider

The author is a native of Vienna, Austria, and a graduate of the University there. He became Vice President of his company in 1939 and has been a Managing Director of Engis Ltd. since 1948. Through his long experience with American and English metal working industries, he has developed a substantial knowledge of die finishing tools and methods, particularly including the use of die finishing compounds and die finish inspection devices of English and German design. Mr. Schneider prepared this paper for presentation at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955.

★ ★ ★

England produces various machines for polishing diamond and tungsten carbide dies, one of which is shown on Figure 2; others are shown as follows:

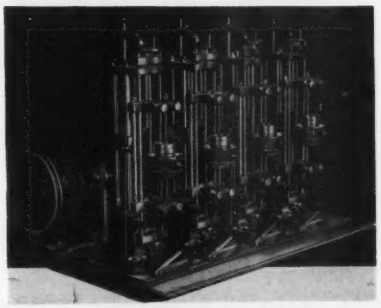


Figure 2.

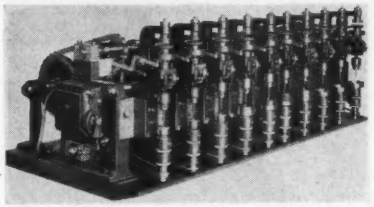


Figure 3.

Figure 3—Piercing and Polishing Machine for diamond and tungsten carbide dies.

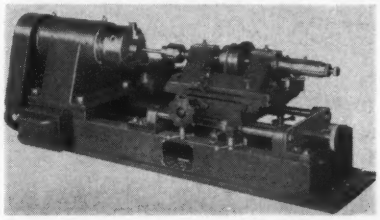


Figure 4.

Figure 4—Lapping and Polishing Machine for Tungsten Carbide Dies.

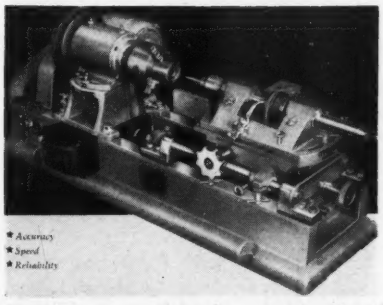


Figure 5.

Figure 5—High-Speed Universal

Lapping and Polishing Machine for Tungsten Carbide Dies. This machine is said to be unusually flexible in all adjustments and to be accepted in many parts of the world, including the Continent.

★ ★ ★

I am sure that the opinion of the real experts on whether any of these machines show significant advantages or differences against American design should be of interest to the industry.

★ ★ ★

In the manufacture of diamond dies England is using rather extensively the electric spark method of piercing and partial finishing. Some of the major diamond die users have gone very far in analyzing all problems surrounding diamond die manufacture because apparently they have not been blessed with a cooperative die manufacturing industry such as our country has produced.

★ ★ ★

One story which was told to me by the chief of one of the leading laboratories engaged in such work will illustrate the English approach to the problem as well as the human element involved in the judging of diamond die quality. It became apparent some years ago that diamond die quality was judged by very personal standards and no progress had been made towards a universal and definite method of acceptance or rejection. In order to determine fairly each company's individual practice die producers, and the wire industry agreed on identical sets of dies to be produced by each company. Each set was coded and judged by all participants. One of the startling results was that in at least one case a participant condemned his own dies in strong language as entirely unsatisfactory. It became very apparent that generally dies were considered bad which very likely would have been found acceptable had the judge known who made them, and vice-versa.

★ ★ ★

This incident proved so educational that it clearly indicated the need for a more universal standard.

Fortunately on tungsten carbide dies the standards of judgment are not as personal and it is possible to judge by more reasonable and independent considerations.

★ ★ ★

But to return to the question of producing die shape and finish.

★ ★ ★

In the line of accessory tools, a reciprocating power driven hand

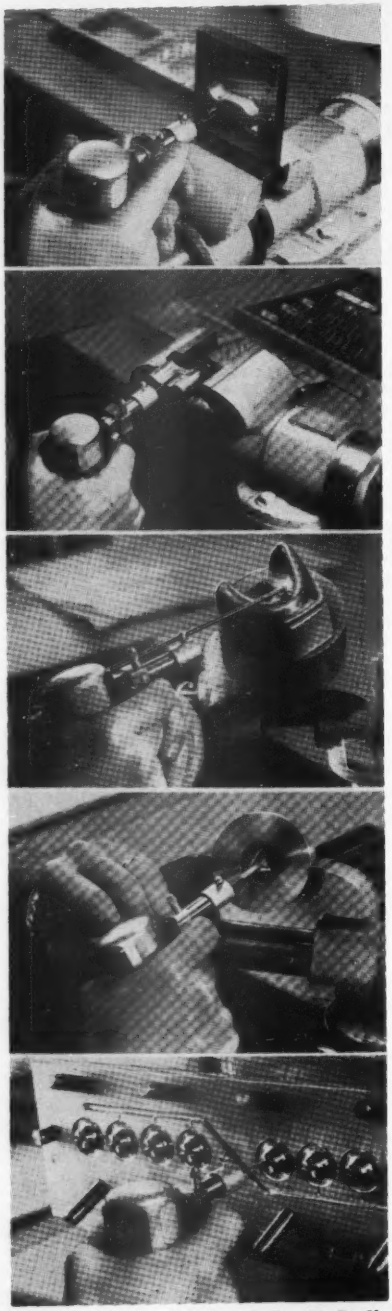


Figure 6. Series of views of the Die-Profiler showing applications.

tool has introduced itself over the last years which appears to be sufficiently light to leave proper "touch" where required and to have a wide range of speed and stroke adjustment. The Di-Profiler, as this device is called, is shown in Figure 6. Its primary use is in shaped dies although it is also useful for other finishing work in the industry.

★ ★ ★

In tungsten carbide as well as diamond drawing dies, diamond powder as an abrasive plays an exceedingly important part. The development of diamond compounds has in the last few years helped to standardize and thereby improve finishing methods all over the world. The compound idea, having started in this country, was looked upon in Europe with considerable suspicion. The industrial diamond producers whose interest normally lies in increased consumption of their product did not take kindly to a technical development which had to reduce industrial diamond consumption to make it pay. The producers of diamond powders did not necessarily approve of a standard ready-made abrasive which added to the skill of crushing, cleaning and grading of diamond particles, the necessity of a sound chemical engineering approach. Finally the consumer, as the ultimate judge, had to be shown that his own craftsmen breaking up boart in a pestle for many decades did not know as much as of these restless innovators who never wanted to leave well enough alone. But as there are diamond compounds now used for wire die finishing from Australia to Switzerland and from Germany to Mexico City, with a substantial number of manufacturers in many of the world's important industrial centers, it may be assumed that diamond compounds are here to stay and, I might add, that in many cases the error of original doubt and opposition has been graciously acknowledged and corrected.

★ ★ ★

Speakers in past years have talked to you about what is necessary in a diamond powder of greatest cutting power and best quality,

so I need only review the subject briefly.

★ ★ ★

Required are:

a. **A proper raw material which is not affected by previous use;**

b. **a proper crushing procedure which pays attention to desired uniform shapes and sharp cutting edges;**

c. **a proper cleaning method which eliminates impurities down to the last trace; and**

d. **finally—and perhaps as important as all the preceding—proper grading procedure which establishes uniformity of size, without larger particles which scratch and destroy the finish produced and free from undersized particles (fines) which produce no work although they must be paid for.**

★ ★ ★

I believe that we may take for granted that there are now in this country—and perhaps to some extent abroad—reputable producers of diamond powders who have accepted national standards so that the user may well be sure of what he gets. In this respect the wartime investigations of our Bureau of Standards still show their beneficial results and competition among the leaders in the industry centers around efforts to produce powder better than the standard. With them, it is no longer a question as to who complies with the standard and who does not.

★ ★ ★

England has recently adopted a standard for diamond powders which in the subsieve sizes appears quite different from our own although in theory more so than in practice. But International Standards and their differences could well be the subject of an entire paper. But all in all, diamond powders of best quality can now safely be considered as available and the problem solved in its technical aspects. However, the diamond compound is emerging more and more as an important problem of physical and chemical engineering because it is much more than a mixture between diamond powders and some oil or grease—just as a good grinding wheel is more than a mixture of abrasive grain with some binder.

★ ★ ★

The proper diamond compound, as we see it, may be compared to a sponge in the pores of which the diamond particles are held uniformly distributed and well separated—as the sponge holds drops of liquid. As you squeeze the sponge, liquid should come out gradually as the work requires. The sponge should be clean and not scratch the surface being wiped. So, in the diamond compound, diamond particles should be released to their greatest effective cutting power as pressure and speed are applied. The wrong kind of sponge will not hold the liquid well; it will not be sufficiently elastic and it will not absorb dirt that you may pick up from the surface which you are wiping. So with the diamond compound, abraded material must be absorbed, self-lubrication provided with proper cutting action under proper operating pressures, speeds and temperatures. So much is being learned about the cutting action of all types of tools—and the diamond powder particles certainly belongs among them—that while much has been accomplished, much more yet remains to be done to put diamond compounds to their fullest application in the general finishing and, more particularly, the wire die finishing field. Competition within the industry will

(*Please turn to page* 1303)

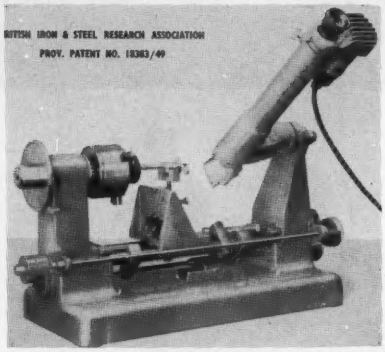


Figure 7.

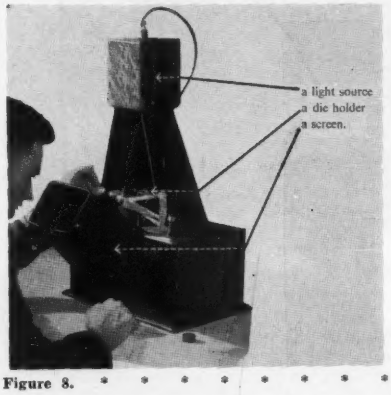


Figure 8.

Figure 9.

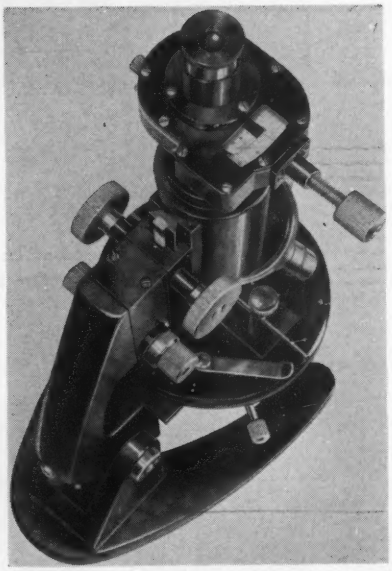


Figure 10.

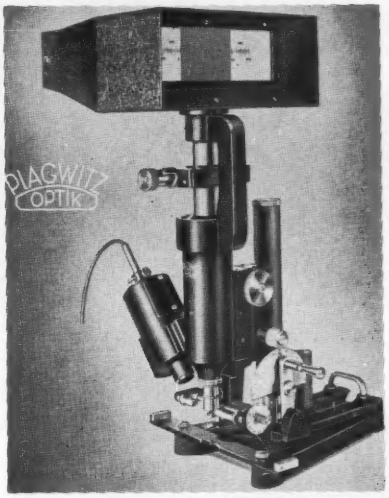
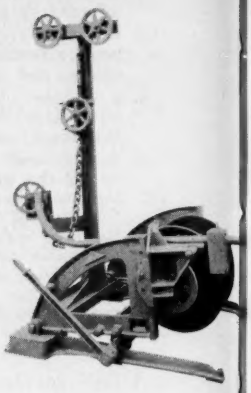


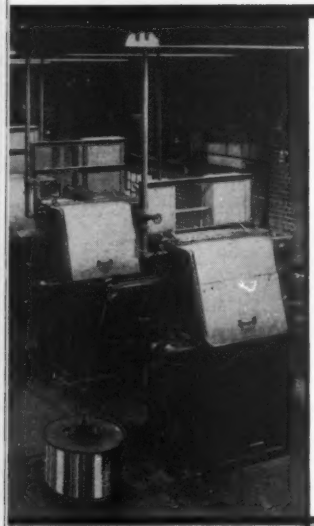
Figure 11.

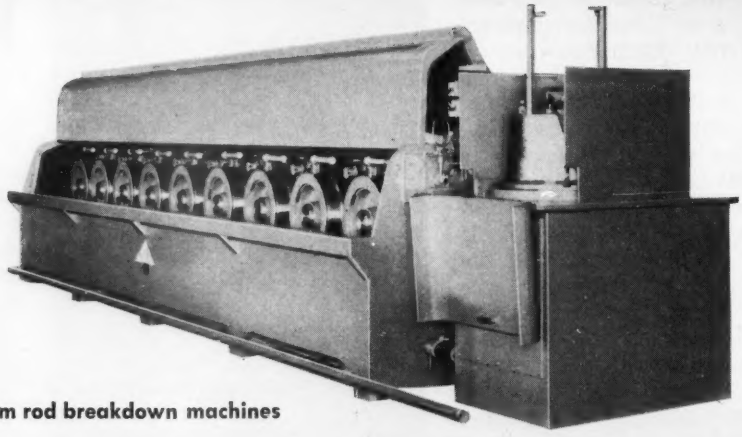
the complete

Type F combined rod breakdown, continuous electric annealing and continuous NON-STOP spooling



Constant tension payoff stands





Tandem rod breakdown machines

Syncro Machine

PERTH AMBO

AFFILIATED COMPANY: WINGET-SYNCRO LTD

MANUFACTURERS OF: WIRE DRAWING MACHINES • STRANDERS • CONTINUOUS ELECTRIC ANNEALERS

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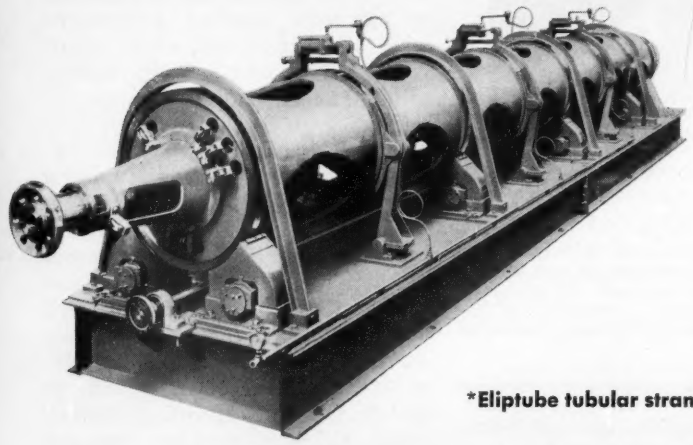
for greater wire profits...

Whether it's continuous rod breakdown, wire drawing, and continuous annealing, stranding or cable taping of copper, aluminum and their alloys — Syncro's entire line of dependable wire and cable machinery is designed and engineered for greater profits through greater production. Write for information on any production problem — complete design and engineering facilities are at your service.

Cable taping machines



*Eliptube tubular stranders

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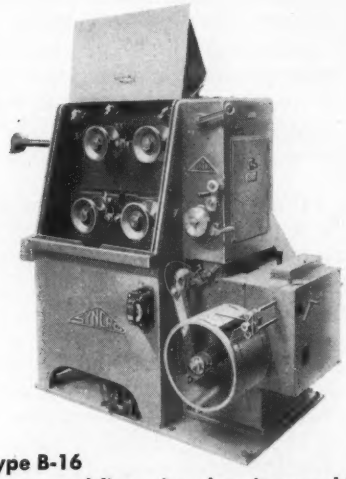
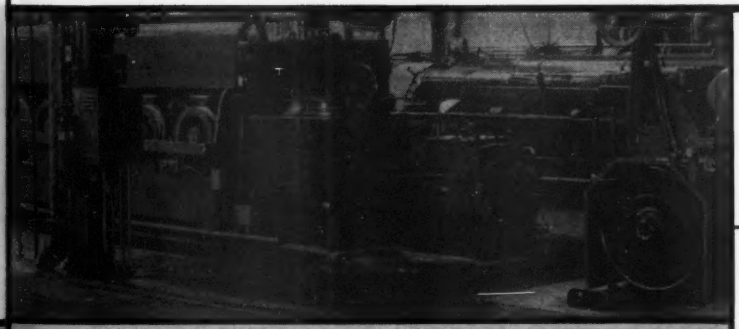


Type B-16
coarse and fine wire drawing machines



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SYNCRO

Better Machinery for the Wire Industry

A Practical Psychological Approach to Quality Control

by Glenn R. Lee
Wire Mill Superintendent
Continental Steel Corporation
Kokomo, Indiana

Continental Steel Corporation is one of the leading industries in Kokomo and currently employs around 2700 people. It has five 135 ton open hearth furnaces which produce around 350,000 tons of steel annually. Our steel production primarily goes into the making of sheet and wire products.

★ ★ ★

Our company's growth and reputation as well as the companies you people represent will always depend on how well we serve the customer. A company doesn't build a good reputation overnight. It is built over many years and by every member of the organization. If you stop and think about it, there is just one way to build a good reputation. It is: To give customers good products and service at a fair price. You can't buy a good reputation. You must earn it.

★ ★ ★

Our companies have always had a standard of quality which they attempt not only to maintain but also to improve.

★ ★ ★

During WW II and the period following, your companies perhaps faced the same problem that ours did; that was, attempting to supply the increased demand of our customers and at the same time maintain our quality standards.

★ ★ ★

Figuratively speaking, when customers were standing at your machines waiting to grab your goods as they were produced, before you had a chance to see them yourself, it was extremely difficult to make the operators of the machines

Glenn R. Lee

The author joined Continental Steel Corporation in 1928 and was transferred to the Wire Mill in 1931. In 1937 he was made Turn Foreman and in 1945 Assistant Superintendent, Wire Mill. He was appointed to his present post in 1949. This paper was prepared for presentation at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955.

realize that quality was an important factor in their production. Consequently many operators got into the habit of allowing little things to slip by.

★ ★ ★

We consider satisfactory quality to be one of the laws of sound economics. These laws, which if adhered to, should provide a certain degree of economic security. However, some people fail to understand, some disregard, while apparently others just don't believe in them.

★ ★ ★

When equipment and materials became available at the close of W W II plans were made to put into operation a new continuous rod mill. In February 1954 this mill was started. It was the first step in an expansion program designed eventually to double our wire drawing capacity.

★ ★ ★

Naturally we encountered the problems inherent in a major change such as this and at the same time revolutionary practices in our wire drawing department were being instituted which created a feeling of insecurity in the minds of many of our employees.

★ ★ ★

We were aware that the quality of an employee's thinking is expressed in the quality of the work he performs. Management recognized the affects of these problems on both materials and personnel and appointed a committee to help correct the situation. This committee consisted of **J. W. Myers** and **R. C. Owen,** Training Department, **C. A. Cooprider,** Superintendent of the Wire Galvanize Department and Chain Link Division, and your speaker.

★ ★ ★

The committee soon realized that our quality problem was not so much one of machines and materials but that of attitudes.

★ ★ ★

As far as the written word was concerned we had very little to help us. Many articles have been written relating to the problem of quality control. These writings have covered the metallurgical and physical characteristics of the materials and methods used in testing these properties and of these we

have an abundant supply. But it seemed to us that not enough consideration had been given to the human element controlling many phases of quality.

★ ★ ★

We can establish rules, laws, methods, practices for the control of quality that are excellent. But quality cannot be inspected or legislated into a product. When it comes down to cases, the real watchdog for quality and the real producer of quality is the man on the job.

★ ★ ★

Doing a good job depends a great deal on the worker's attitude and on the principles he lives by. When he takes pride in his work, he does good work, perhaps excellent work. The first step is to acquire the right attitude. That attitude is: Whatever my job is, I'll do it to the best of my ability.

★ ★ ★

The wiredrawer who comes to the job with all his wiredrawing skills but no desire to do a good job has left his most important tool at home. On the other hand, the employee who takes the right attitude toward his job and his company will put his best effort into his work because he wants to learn and to succeed, is eager to qualify for higher jobs, and is willing to cooperate in his department's and company's efforts for the progress of the business and his own economic security.

★ ★ ★

With this thought in mind we felt that perhaps the thing to do would be to go directly to the people who were processing our goods and give them a picture of the demand for their labor determined by present day competition for the sale of wire now that the supply is plentiful as compared with the demand for wire when the supply is short. Prove to them that if they were to have steady employment that they would have to produce wire that our salesmen could sell.

★ ★ ★

We were not sure just how to go about this. We thought perhaps the best method was to make individual contacts with the workmen right on the job.

★ ★ ★

There were 250 men to be contacted and it was decided that your speaker was the one who should make the contacts. It soon became apparent that this was not the proper method. It was too slow, it would take too long to cover the entire group. Men were skeptical, they thought that they were being singled out and made conspicuous because of poor workmanship. Opposition was being built up in advance because of failure of the majority to understand what was being attempted. In addition there was continual noise and many interruptions during an interview. In situations such as this it was impossible to hold attention and present the complete picture.

★ ★ ★

A few months previous to this, a program of quality and safety meetings was started. This plan included the holding of mass meetings on each turn. All employees on each turn were called together in each meeting. Quality and Safety were alternate subjects monthly. In these meetings, material was presented visually as well as orally.

★ ★ ★

There had been much interest shown in this program and it was considered successful to some extent. In groups of 75 to 100 men from the various jobs throughout the mill it was hard to find subjects in which all were interested. Then too, groups of such size are hard to talk to in a factory building where it is next to impossible to have all equipment shut down. This program, although effective for large groups, did not accomplish our purpose because we felt that the personal approach would be more effective.

★ ★ ★

Because of this experience a new plan was worked out and put into effect. This plan was developed with the objective of acquainting the workmen with the problems involved and an attempt to gain their aid in solving them.

★ ★ ★

The first step of course, was to call in all members of departmental supervision and present the program to them. This gave them advance information on the entire program. Whenever possible the foreman in charge of the group sat in on the meeting and helped guide the discussion. The meetings were conducted in the following manner:

★ ★ ★

1. **Groups of 8 to 12 people were taken from their jobs to attend whenever possible. Care was taken to avoid calling men in on off turns.**

★ ★ ★

2. **The meetings were opened by supervision explaining their purpose and how they were to be conducted. Comparisons were made between the quality requirements of the past and those of the present. Logical reasons for the changes were given some of which were:**
   a. **Present day manufacturing processes require better finishes.**
   b. **The trend to automation requires more exacting specifications.**
   c. **Specific quality requirements of individual customers.**

   Emphasis was placed on the part played by the worker in any quality program.

★ ★ ★

3. **A member of the training department acted as moderator with a member of supervision assisting in steering the discussion.**

   A small dose of practical economics was administered. Each man was asked to tell the moderator the number of years of experience he possessed in the wire mill. This information was recorded in large figures on a flip chart. When the years of individual experience had all been recorded, they were totalled. The statement was then made that it appeared reasonable to assume that the solution to many of our problems could be found in the combined experience of the groups. Actual letters of complaint were used to stimulate discussion which tended to remove any doubt of the seriousness of the subject in the worker's mind.

   Every effort was made to get suggestions for corrective measures from the workers. A blackboard or flip chart was used to good advantage in aiding the more experienced workers to explain pertinent points to the less experienced.

(*Please turn to page* 1300)

Mineral-Insulated Metallic-Sheathed Cables

by

G. S. Eager, Jr. *
Assistant Director of Research

S. P. Lamberton **
Research Supervisor

General Cable Corporation
Bayonne, New Jersey

A paper prepared by the authors for presentation at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955.

Introduction

A new type of mineral-insulated electrical cable rated 600 volts is being manufactured in this country. Only two basic inorganic materials go into the make-up of this cable; copper, for the conductors and seamless outer sheath, and highly compressed magnesium oxide for the insulation. This cable is completely self-contained within the seamless metal sheath and is the first cable for general use to be completely non-flammable.

★ ★ ★

It is the purpose of this paper to describe mineral-insulated metallic-sheathed cables and their terminating fittings, to present the principal properties and characteristics of such cables, and to indicate some of the unique features which make these cables advantageous for many applications.

History

The use of certain minerals as electrical insulation has interested cable engineers for a number of years. Magnesium oxide or aluminum oxide in powder form have been used for the electrical insulation of heating elements with an overall enclosing metallic sheath. It has been recognized that the properties of resistance to extreme heat and the inherent stability of these minerals offer unique advantages as insulation for electrical wires and cables.

★ ★ ★

Mineral-insulated metallic-sheathed cable, although new in this country, has had many years of commercial use in Europe. In 1934 the first successful commercial production of mineral-insulated copper cables was started in France by Societe Alsacienne de Construction Mechaniques. Up until this time there had been no satisfactory commercial method of fabricating a mineral-insulated cable in long continuous lengths that would be required for general use. This cable, known as Pyrotenax, was developed to meet the need for a wiring system which would be completely non-flammable and able to operate continuously as a current-carrying medium even when subjected to fire. One of the earliest and most notable applications for this new type of electric cable was its use as the wiring material in the Louvre Museum in Paris, France in 1936. Up until this time no artificial lighting had been permitted because of the possibility of fire and the resultant damage to the great collections of art treasures for which the Louvre is famous.

★ ★ ★

In 1937 production of this type of cable began in England and its use in that country spread rapidly. In addition to industrial and electric utility applications it was used by the British Admiralty on naval vessels, principally as high frequency cable for radar installations.

★ ★ ★

The company with which the authors are associated now has mineral-insulated metallic-sheathed cable in regular production. Considerable time and effort has been spent to develop adequate fabrication techniques and processes, materials control, and product design.

CABLE MATERIALS AND CONSTRUCTION

Sheath and Conductors

Copper is used for the conductor and the outer sheath. In those applications where the copper sheath would be subject to attack by corrosive agents, such as certain acids and chemicals, protective coverings can be applied to the sheath. For high temperature applications the copper sheath is satisfactory for continuous operation up to 250 C.

★ ★ ★

In addition to the regular copper Type MI power cables there is a special cable for heating service. The heating cable is a small two-conductor cable which utilizes copper-nickel alloy resistance wire for the conductors and a standard copper sheath.

★ ★ ★

Insulation

The insulation consists solely of tightly compressed magnesium oxide. Magnesium oxide is obtained by calcining magnesium carbonate (magnesite) which is found in nature. India is a principal source for the magnesium oxide used for electrical insulation. The electrical properties of magnesium oxide are affected by its source, amount of impurities and degree of calcination and these properties are carefully controlled by chemical analysis.

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Magnesium oxide is chemically stable with temperature up to its melting point at 2800 C. It is however, hygroscopic and absorbs moisture to form magnesium hydroxide which deteriorates its properties as an electrical insulator.

The absorption of moisture by the insulation, which would normally occur only at an end of the cable, does not permanently damage the insulation. Its original properties can easily be restored by driving off the moisture by the application of heat to the cable for a distance of approximately one to two feet from the end. This can be conveniently done with a blowtorch. An alternative method would be to cut off the end of the cable for a distance of six inches to two feet depending on the time and conditions of exposure. Since terminating the cable requires removal of the outer sheath and insulation for a distance of six to eight inches, this operation removes the magnesium hydroxide which may have formed by short-time exposure of the cable end to the atmosphere and automatically restores the original properties of the insulation. The presence of moisture in the insulation is readily detected by a test for insulation resistance. The hygroscopic nature of the magnesium oxide makes it necessary to keep the ends of the cable sealed. Cable end seals are available which are easily applied and provide the necessary protection against moisture. These seals together with the associated mechanical fittings will be described in a later section.

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Sizes and Constructions

Table I gives the standard size ranges for the various cable constructions and the significant dimensions of the smallest and largest cable in each size range for single and multi-conductor power cables and for the special 300 volt rated heater cable.

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The separation between surfaces of adjacent conductors (insulation thickness) is identical with that between surfaces of outer conductors and sheath. The thickness of insulation in 600 volt Type MI power cables varies with conductor size, ranging from about 0.060 inch for the smallest sizes (16 AWG) to about 0.080 inch for the largest size (4/0 AWG). The insulation thickness of the special 300 volt rated heater cable previously mentioned is 0.043 inch. The thickness of the copper sheath for all cables varies linearly with cable diameter from 0.023 inch for the smallest size to 0.039 inch for the largest.

Method of Fabrication

There are two methods of assembling the component parts of the cable (outer copper sheath, magnesium oxide insulant and conductors) prior to the drawing and annealing operations. In the older method, the hydrated magnesium oxide in powder form is molded into cylinders under great pressure, approximately two inches in diameter and length, with as many accurately spaced holes through the body of the cylinder as there are conductors in the cable. After molding, the hydrated magnesium oxide cylinders are completely dehydrated in electric furnaces. The cylinders are then placed inside a seamless uncoated copper tube whose inside diameter is slightly larger than the diameter of the molded cylinders. Solid uncoated high conductivity copper rods are then inserted in the holes in the magnesium oxide cylinders to complete the starting assembly. After sealing the ends of the filled copper tube it goes through a series of drawing and annealing operations. A more recent method of assembling the component parts to provide the starting assembly is now coming into use. The copper rods (conductors) are accurately positioned within the copper tube automatically by the new assembly machinery. The tube is continuously and automatically filled with the pretreated and dehydrated magnesium oxide powder, and tamped in place to provide a uniform density of the insulant throughout the length of the starting assembly. This method is faster than the previous one; it likewise produces accurate spacing of the conductors with uniform insulation thickness.

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In the drawing process the compressive forces compact the magnesium oxide and produce a dense homogeneous mass of magnesium oxide which transmits the compressive forces to the copper rods. All members, copper tube, copper rods, and magnesium oxide, maintain the same relative position one to the other while being proportionally reduced in diameter and cross section, and increasing in length, during the drawing process. The assembly is annealed at intervals during the drawing process to eliminate the effect of work-hardening on the metal and the finished cable is supplied fully annealed.

PROPERTIES OF FINISHED CABLE

Electrical Properties

The electrical properties of this

Table I

STANDARD SIZE RANGES AND PRINCIPAL DIMENSIONS FOR TYPE MI CABLE

Number of Conductors	Size Range AWG	Conductor Diameter Nominal, Inch	Cable Diameter Nominal, Inch	Weight Approx. lb/1000 ft.
Power Cable, 600 Volt				
1	16 to 4/0	.051 .460	.215 .699	78 1061
2	16 to 4	.051 .204	.340 .684	167 734
3	16 to 4	.051 .204	.355 .730	185 902
4	16 to 6	.051 .162	.387 .684	218 786
7	16 to 10	.051 .102	.449 .621	294 622
Heater Cable, 300 Volt				
2	-	.038	.246	91

cable, as measured on samples of finished cable, are shown in Table II. The data shown are average values at room temperature measured at 60 cycles per second except insulation resistance which was measured at 500 volts, d-c.

Table II

ELECTRICAL PROPERTIES OF MINERAL-INSULATED CABLE

Insulation Resistance "K", megohms - 1000 ft	400,000
Power Factor, percent	0.08
Dielectric Constant (SIC)	3.8
Dielectric Strength, volts/mil	60

The insulation resistance is higher than any extruded insulation in common use on low voltage cables except polyethylene. The power factor compares favorably with that of polyethylene. The dielectric constant likewise is appreciably lower than most rubber or thermoplastic insulating compounds in common use, except polyethylene. The dielectric strength is appreciably lower than conventional rubber or thermoplastic insulations but is adequate for service at 600 volts. All cable is subjected to a final dielectric strength test of 2500 volts, for five minutes at the time of manufacture. Although the initial dielectric strength is low the cable is unique in that a simple dielectric failure, which is not accompanied by a power arc to melt the copper, is self-healing and does not impair the normal dielectric strength of the cable. The insulation resistance decreases with increasing temperature. Figure 1 shows typical data for a single conductor 4/0 AWG cable measured at 500 volts d-c after a one-minute electrification time. The power factor of magnesium oxide insulation is independent of frequency. The change in power factor with temperature as measured at 1000 cycles per second is indicated in Figure 2. The dielectric constant of magnesium oxide is likewise independent of frequency. It is essentially constant at 3.8 up to a temperature of 200 C; at 300 C it is 4.0 and increases slowly with temperature; at 600 C it is 7.8 and increasing rapidly. The dielectric strength of Type MI cable at 60 cycles per second decreases with increasing temperature as indicated in Figure 3.

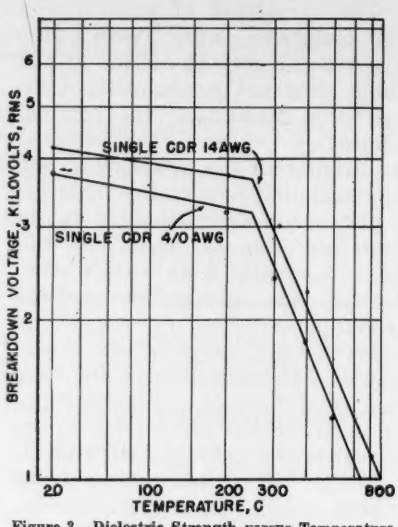

Figure 3. Dielectric Strength versus Temperature, Type MI Cable.

The abscissae of Figures 2 and 3 show temperature, but the values are plotted on the basis of the reciprocal absolute temperature scale. These figures were originally presented by Jordan and Eager in reference 1.

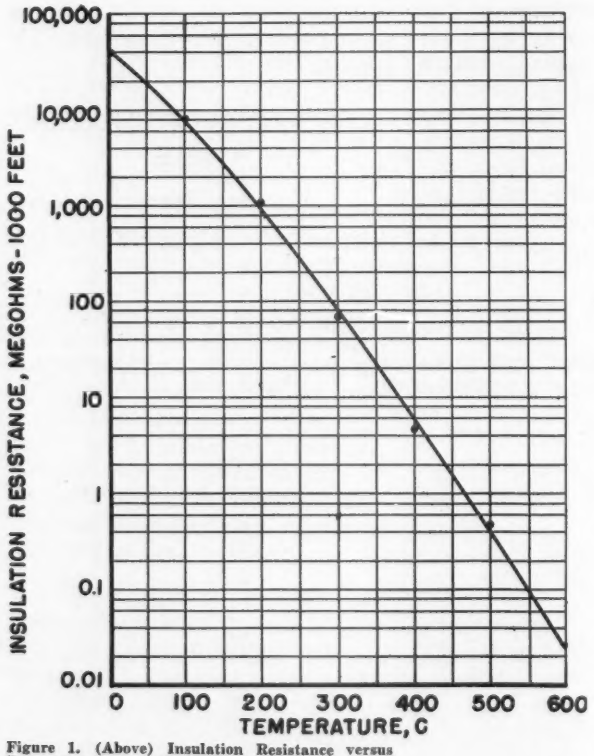

Figure 1. (Above) Insulation Resistance versus Temperature Type MI Cable, Single Conductor, 4/0 AWG.

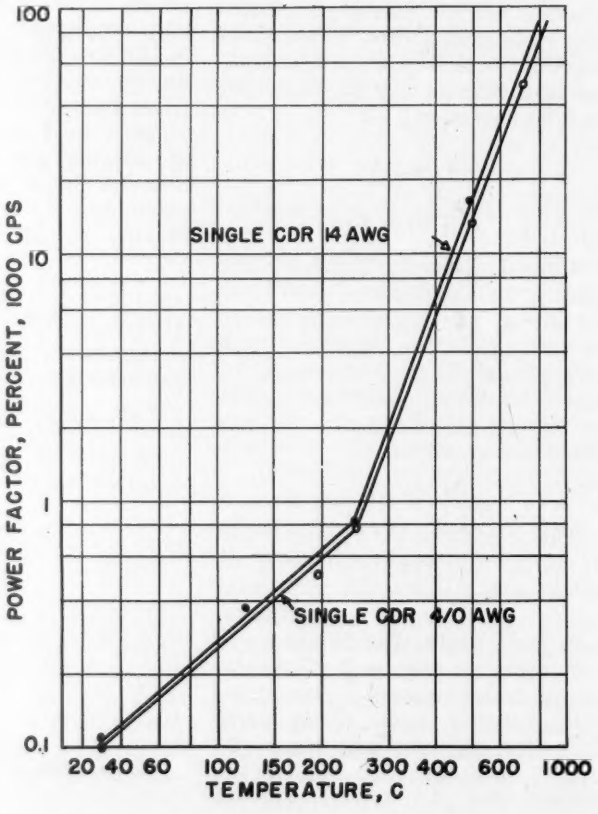

Figure 2. (Right) Power Factor versus Temperature Type MI Cable.

Mechanical Properties

The physical toughness of this cable and its ability to withstand severe mechanical abuse is exceptional. Comparative mechanical tests with conventional cable types are summarized in Table III.

Table III

MECHANICAL TESTS ON MINERAL-INSULATED CABLE

	Type MI	Armored Cable	EMT Type R	Rigid Conduit Type R
Impact	B	D	C	A
Crushing	A	D	C	B

Notes: Performance is indicated by letter "grades;" A signifies best performance. EMT is electrical metallic tubing, Type R refers to Underwriters' Code Grade rubber insulated conductors. In the impact test, the cable was laid over an anvil hardy having a smoothly rounded edge with a 1/4 inch radius. Weights of 50, 20, and 10 pounds were dropped on the cable and the length of drop determined which produced not more than two failures in ten separate blows. In the crushing test the cable was crushed against the same anvil hardy used in the impact test by a flat steel plate in a compression testing machine. The force required to crush the cable to 50 percent of its original diameter was determined.

Thermal Properties

The thermal properties of this cable are outstanding. The high thermal conductivity of the insulation, three to five times greater than most organic insulations, greatly facilitates the transfer of heat from the conductor to the sheath where it may be dissipated. The cable is completely non-flammable and does not produce any toxic or flammable gases when subjected to temperatures up to the melting point of the copper sheath, 1083 C. The maximum temperature for continuous operation is basically limited by the effects of oxidation on the copper sheath. Investigation has shown that a maximum operating sheath temperature of 250 C will not decrease the life of the cable to any significant degree. The calculated decrease in copper sheath thickness as a function of time at various temperatures is shown in Table IV.

Other Properties

The impervious copper sheath protects the cable from moisture and humidity. The end seals which are supplied with the cable prevent the entrance of moisture into the cable ends. The cable resists oils, gasoline, solvents, and some acids due to the protection of the outer copper sheath. There is no limit of low temperature flexibility imposed by the cable insulation; the end seal is the limiting factor.

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The finished cable is fully annealed and has the same flexibility as comparable sizes of annealed solid copper conductors or tubing. The cable can be handled under normal and abnormal field conditions without physical or electrical damage. The few techniques required for installing Type MI cable are simple and easily learned.

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TERMINATING FITTINGS

Standard Fittings

Standard fittings for terminating mineral-insulated cable are available from the cable manufacturer.

Table V

DECREASE IN COPPER SHEATH THICKNESS VS. TIME

Thickness Decrease, mils*	250 C	400 C	800 C
1	2.6 years	0.06 years	0.26 hours
2	10.3 years	0.23 years	1.04 hours
5	64.3 years	1.5 years	6.5 hours
10	257 years	5.8 years	25.9 hours

*1 mil = .001 inch

There are only two types of standard terminating fittings, (1) the cable seal termination and (2) the gland. The cable seal termination (Type 0) is a fitting designed to provide a moisture-proof seal for the end of the cable and to insulate the bare conductors; it is intended for a maximum operating temperature of 85 C. The gland is a fitting whose sole purpose is to provide a means for mechanically fastening the end of the cable, with a cable seal termination attached, to a standard outlet box, distribution panel, etc.

The Cable Seal Termination

The cable seal termination consists of the following parts which are furnished complete in kit form:

1. **"Screw-on-Pot," a brass cylinder, self-threading.**
2. **Neoprene tubing, .036 to .056 inch nominal wall thickness, supplied in 12 inch lengths for each conductor.**
3. **Beads to anchor neoprene tubing to insulating cap.**
4. **Insulating cap, a rigid phenolic composition 3/32 to 3/16 inch thick.**
5. **Sealing compound, a soft plastic compound.**

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After removing the copper sheath with the stripping tool to expose a sufficient length of conductors for the necessary connection, the "screw-on-pot" is screwed on the end of the copper sheath; it cuts its own thread in the copper sheath. The neoprene tubing is cut to the proper length, inserted in the holes in the insulating cap and fastened in place with the beads. The "screw-on-pot" is packed with the plastic sealing compound, designated as Type 0 for 85 C rated terminals. The insulating cap with the neoprene tubing is then slipped over the conductors and pressed tightly against the recessed shoulder in the end of the "screw-on-pot" and by means of the simple crimping tool is seated in the end of the "screw-on-pot" and securely crimped in place. This provides a permanent moisture seal over the magnesium oxide insulation and insulates the conductor. Figure 4 shows a cable seal termination and its component parts for a two-conductor Type MI cable.

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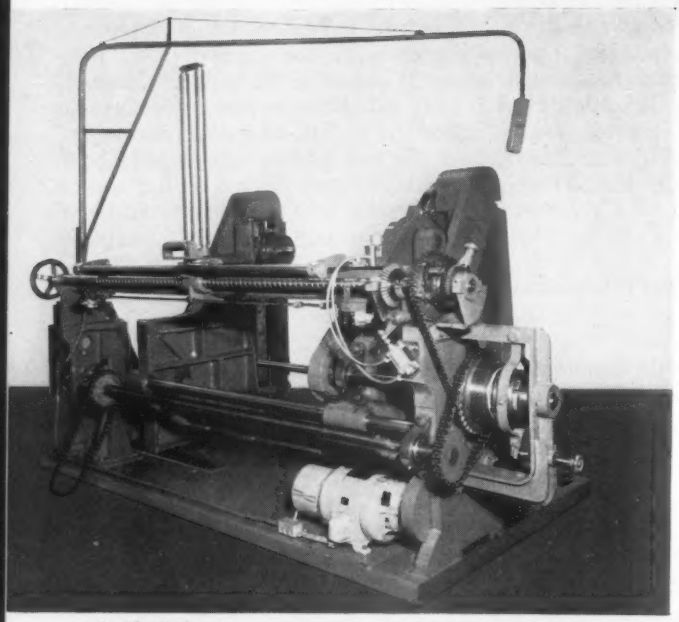

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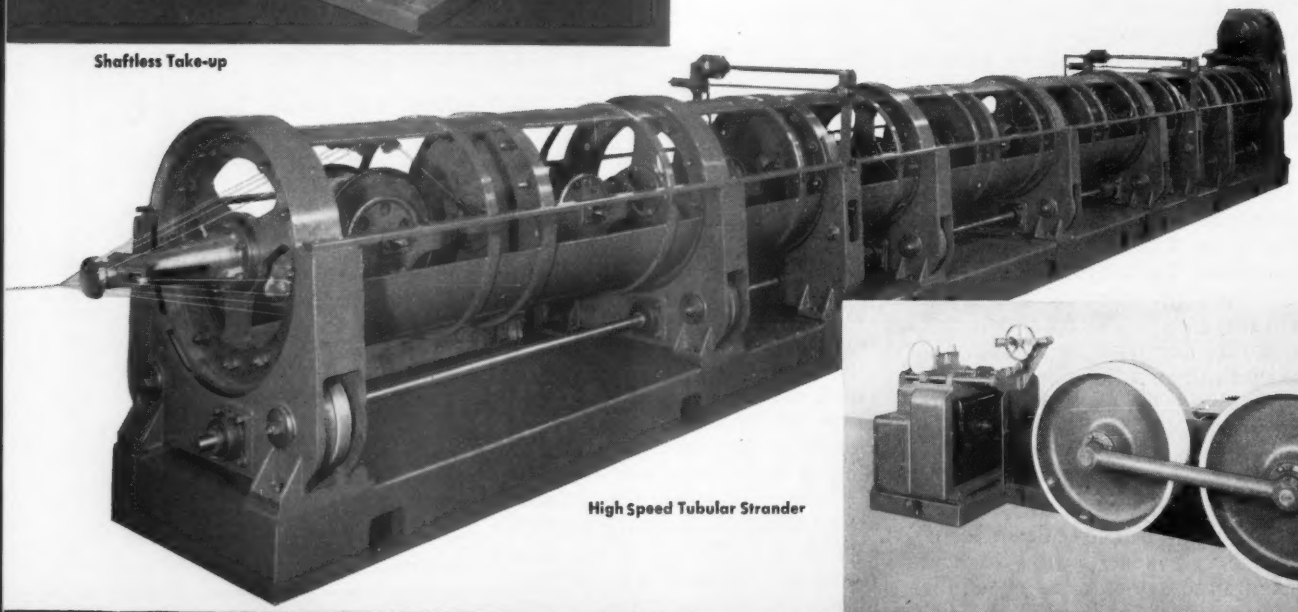
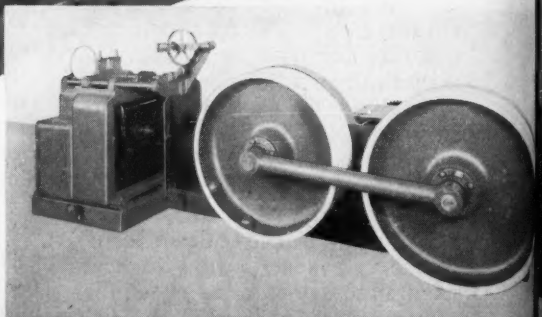


High Speed Tubular Strander



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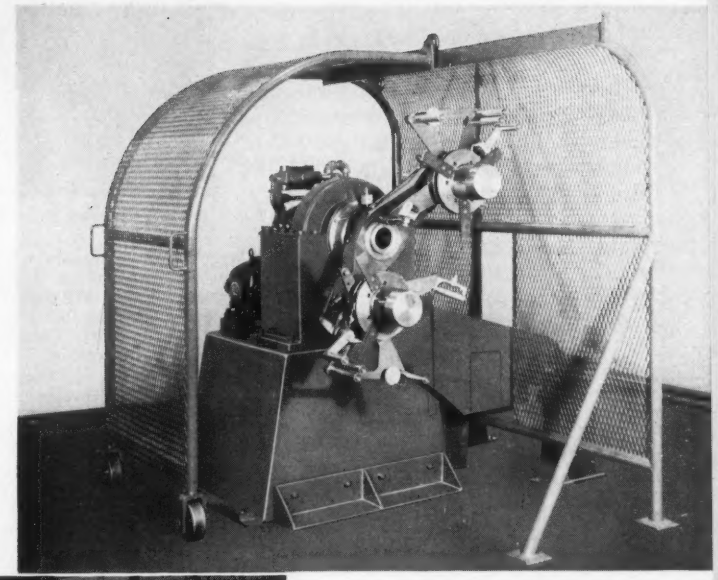
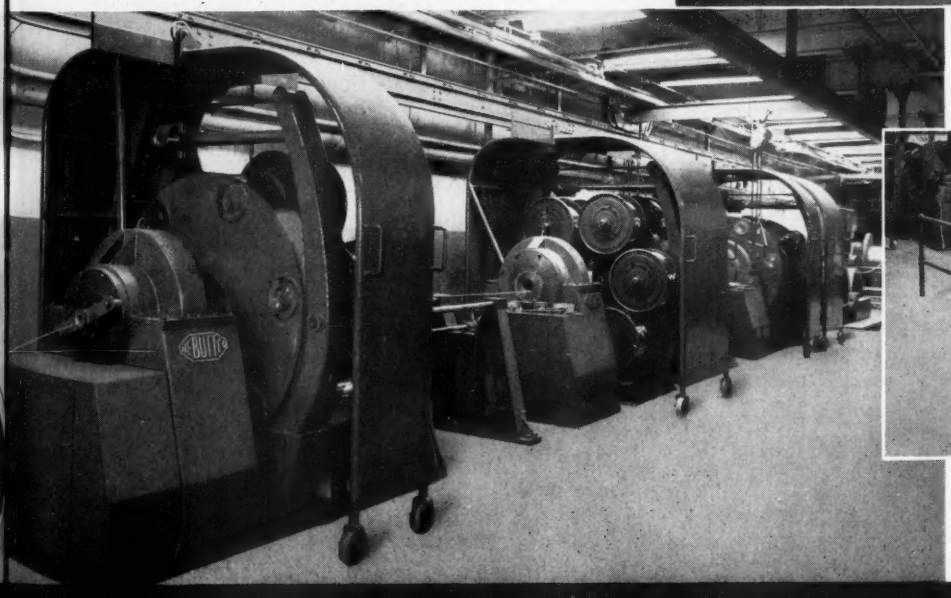
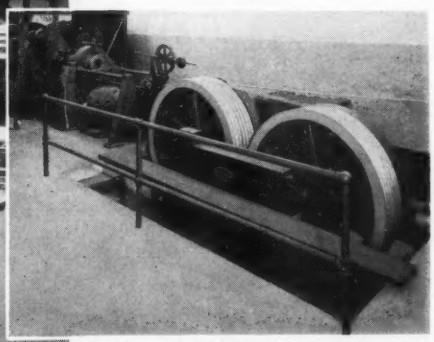


Eccentric Taping Head





Rigid Strander

Providence 7, Rhode Island, U. S. A.

Drawing and Processing of Titanium Wire

by Douglas H. Wilson, Production Department
Rem-Cru Titanium, Inc.
Midland, Pennsylvania

Background

1. **Necessity** for wire products:
   a. Welding—other titanium products: sheets, bar, etc.
   b. Fasteners
   c. Other uses: filter screens in chemical industry
   d. Wire rope, etc.

History

Late in 1949 the first wire was made by hot hand swaging—½" round forged bar, with approximately 1/16" reductions to smaller sizes — smallest diameter 3/32" round. All experimental grades produced—**Milford Rivet Co.**, Milford, Conn. — small rivets—from A-70.

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North American - Philips Co., Lewiston, Maine, drew material to .005" round—small quantity of A-55.

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Typical physical properties of A-55, A-70 and C-130AM are as follows:

A-55:	65,000/85,000 psi Ultimate Strength 25 to 30% Elongation (4d gauge length)
A-70:	90,000/110,000 psi Ultimate Strength 20 to 30% Elongation (4d gauge length)
C-130AM:	140,000/160,000 psi Ultimate Strength 10 to 20% Elongation (4d gauge length)
A-110AT:	130,000/150,000 psi Ultimate Strength 10 to 20% Elongation (4d gauge length)

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Remington Arms joined with **Crucible Steel Company of America** and started development at the Crucible mill at Syracuse, New York, on April 1, 1951.

Processing and Development of Wire at Crucible-Syracuse

The approach and the development of processing titanium wire was based on the general techniques followed in the development of the many steel alloys processed by the Crucible Steel Company of America (Syracuse Mill). This approach was established as the following general program:

First: Investigation of lubricants and coatings.
Second: Investigation of die materials.
Third: Investigation of die design.

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A complete record of each drawing experiment was made. The records covered (1) complete details of each drawing operation (dies, lubricant, speed, etc.), (2) prior history of material utilized, (3) comments of the working metallurgist, and (4) results of physical test and microscopic analysis of samples after each drawing pass.

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A single die, cold drawing machine, rebuilt with a variable speed drive to give drawing speeds of 100 to 1500 ft. per minute, was utilized for all development work. This machine had a standard 22" drum. The die holder was water-cooled and the die box built to handle all types of lubricants.

Investigation of Lubricants and Coatings

The first experiments were made using the Rem-Cru A-55 commercially pure titanium grade because of its lower hardness, lower strength and greater ductility.

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The purpose of this phase of development was to find a lubricant capable of protecting the wire surface from becoming scratched or galled—a lubricant that would allow reductions of 20% or greater at speeds in feet per minute as great as possible. The lubricant must also be readily applied, readily removed, and must have no chemical reaction with the base material.

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Approximately thirty lubricants, including liquids of various viscosities, greases and dry powders, were used. None of these lubricants proved successful when applied at the die. On the descaled and pickled wire the lubricants failed in their ability to form a uniform adherent coating. Roughing the surface of the wire was done by various pickling techniques to allow better "pick up." Some improvement was noted, particularly with the heavy viscosity liquids, although galling and scratching, resulting in break-

Douglas H. Wilson

Mr. Wilson is employed in the Production Department of Rem-Cru Titanium, Inc. He started his career with the titanium industry at Remington Arms Company, Bridgeport, Connecticut in 1948. After the formation of Rem-Cru Titanium, Inc., Mr. Wilson was transferred to the Sanderson-Halcomb Works of Crucible Steel Company of America at Syracuse, New York, where he is now responsible for all Rem-Cru operations in the production of titanium billets, bars, wire and forgings. Mr. Wilson received his B. S. in Mechanical Engineering and advanced education in metallurgy at the University of Rochester, Rochester, New York.

This paper was prepared for presentation at the Annual Convention of The Wire Association in Chicago, November 14-17, 1955.

age at die, still persisted. Galling tendencies on titanium created a serious problem with the heat of friction and breakdown of lubricant. The metal would weld to the die thus causing severe scratching, galling and breakage. This property of titanium metal is exhibited by drawing a piece of the metal across glass. Even at room temperature and with hand pressure the metal will mark glass. This property is often used to identify titanium from other metals.

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Coils were then coated with a commercial compound and a heavy lime dip-coat. Tests were run again using the various secondary lubricants at the die. Some improvement was noted, if the original coil surface was rough. After one pass this condition was lost and results were no better than that obtained with the bare wire.

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In the interim, work was progressing with the coating of titanium with copper, lead or its own oxide.

Lead Coating

Attempts to lead coat titanium wire were unsuccessful. The lead would not form a uniform coating by the dip method. Any attempts to "dip" and "wipe on" the lead resulted in complete removal of the lead from the surface. Various pickled surface conditions of the coils and various temperatures of the lead bath were used in this work. No attempts were made to draw any wire in this condition.

Copper Coating

Some greater success was developed with the copper coating. Under close control by the electrolytic method a coat was applied to the wire. The coat was generally uniform but in many cases "bare areas" were present. Only under laboratory conditions did the application of the copper coat appear to be satisfactory. The coat produced was by a mechanical bond. The coat would usually "peel" or loosen from the surface during handling or the first cold pass such that successive drawings could not be made. Attempts to recopper between passes were unsuccessful as the surface was too smooth or "tight" from the first cold pass and would not allow the copper to form a mechanical bond. Attempts to copper coat wire that had been first oxidized gave the same results as with the bare wire.

Oxide Coat

The principle of using an oxide coat of titanium as a primary lubricant was first used in 1951 in the production of the first welded titanium tubing processed at **Trent Tube Company**, East Troy, Wisconsin, for A.E.C. Since strand line annealing equipment was not available, extensive trials were necessary to find the correct furnace temperature and furnace atmospheric conditions to impart a tight, uniform oxide film on the coils. It was found that a furnace temperature of 1300°F and approximately 3% oxidizing atmosphere proved most satisfactory. The following process was established as the most suitable for lubricating titanium wire for cold drawing:

1. **A 1300°F oxide film.**
2. **A lime coat (dip method).**
3. **A final drawing lubricant of five parts soap and one part molydisulfide.**

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It was found that the process of oxidizing the coils would also serve as an intermediate anneal. This is a very important feature from the standpoint of hydrogen pick-up.

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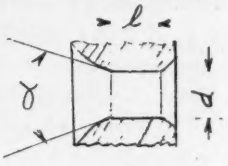
Under these conditions reductions up to 30% per pass at speeds over 100 ft. per minute were achieved. Total combined reductions were established at approximately 50% between anneals.

Die Material

The next step was to study die material. Little effort was spent on this project as it was soon learned that only carbide dies were suitable. It was finally decided that tungsten-carbide dies of the 779 grade were most suitable.

Die Design

The third project then was die design. The basic design used in the preliminary experiments was 16° approach angle, 20% bearing and 90° back relief angle, all angles blended smooth.



α = approach angle
l = bearing length = ⅝ x d
d = dia. of bearing section of die

Because of titanium's resistance to flow, the first approach was to reduce the bearing surface. Starting at 5%, the bearing surface was progressively increased to approximately 30%. At this stage the die pick-up and loss of reduction per pass limited any further increase. No work was done on the approach angle as it was felt the original 16° approach angle was satisfactory. The following die designs were then established:

1. **For breakdown passes:**
   16° approach
   10% bearing
   90° back relief
   All angles smooth blend
2. **Finishing pass:**
   16° approach angle
   20% bearing
   90° back relief angle
   All angles smooth blend

Center Condition

Throughout this development work microscopic examination of samples from hot rolled rod to finished 1/16" round continued to disclose a "center condition." This condition was of the nature of a "burst" that progressively became worse as the sectional area was cold reduced. It was determined that the source of this problem was the heavy straining and finally rupturing of the center of the roads during the drawing operation. Change of (1) billet size, (2) rolling temperatures, (3) final size and (4) final anneal of rods prior to drawing eliminated the presence of any voids. A "work pattern" still persisted in the hot rolled rods, although micro examination, fracture tests and tensile tests showed material was ductile and sound with a fine uniform grain structure. Cold working of these rods still re-

(*Please turn to page* 1305)

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PURPOSES

Its specific purpose is to improve production methods and afford a clearing house for ideas on management problems, technical problems, and research work in all phases of practical wire drawing and wire working, and to develop and maintain friendly relations among the members.

ACTIVITIES

The Association functions along the following lines:

1. The use of the Association headquarters as a central clearing house for information and data of all kinds which may be of interest to members.
2. The exchange of ideas on processes of production including machinery, technical processes, etc.
3. The establishment and maintenance of friendly relations among the members of the association and the development of sectional and national meetings to discuss matters of mutual interest.
4. Studies of production methods and analysis of production costs.
5. Developments in the use of new materials and new applications of existing materials and by-products.
6. Research and collection of information on personnel management, including such factors as labor turnover, seasonal changes in the demand for employees, wage scales, etc.
7. Standardization and simplification as a means for the effective elimination of waste.
8. Such other subjects as may be determined upon.

THE ANNUAL CONVENTION OF THE WIRE ASSOCIATION

LA SALLE HOTEL, CHICAGO, ILLINOIS, NOVEMBER 14-17, 1955

The Wire Association's Headquarters at The La Salle Hotel—Suite 1850—
Will be open from Monday, November 14th, every evening during the convention.
Come and get acquainted.

THERE WILL BE A REGISTRATION FEE OF $11.00 FOR MEMBERS AND $13.00 FOR NON-MEMBERS, INCLUDING AN ANNUAL LUNCHEON TICKET, FOR ALL THOSE ATTENDING THE TECHNICAL SESSIONS AND MEETINGS. PLEASE HAVE YOUR ASSOCIATION MEMBERSHIP CARD WITH YOU AND SHOW IT WHEN REGISTERING.

ADMISSION WILL BE BY BADGE ONLY—PLEASE WEAR IT.

THE WIRE ASSOCIATION PROGRAM COMMITTEE FOR THE 1955 CONVENTION

GENERAL CHAIRMAN
John A. Moritz, President
Standard Industrial Compounds Co.
Chicago, Ill.

GENERAL ACTIVITIES

EXECUTIVE SECRETARY
Richard E. Brown
The Wire Association
Stamford, Conn.

REGISTRATION
R. S. Spengel, Asst. Exec. Secy.
The Wire Association
Stamford, Conn.

ENTERTAINMENT
Eber J. Hubbard, President
Hubbard Spool Company
Garrett, Ind.

All papers presented at the Convention by members of The Wire Association are eligible for consideration for the Annual Medal Award, and will be voted upon by the Board of Directors at the next Spring meeting of that body.

FERROUS DIVISION

CHAIRMAN
Stewart S. Gray, Asst. Vice Pres.
Union Wire Rope Corp.
Kansas City, Mo.

COMMITTEE MEMBERS
Theodore B. Dull
Superintendent, Wire Mill
Sheffield Steel Division
Armco Steel Corp.
Kansas City, Mo.

Edmund D. Sickels, Editor
Wire and Wire Products
Stamford, Conn.

Technical papers are preprinted in the October issue of Wire and Wire Products insofar as possible. Titles to papers accepted will be given to The Wire Association and duly copyrighted at the time of publication.

NON-FERROUS DIVISION

CHAIRMAN
Benoit J. Sirois, Met. Engineer
Phelps Dodge Copper Products Corp.
Elizabeth, N. J.

COMMITTEE MEMBERS
Andrew Pudlak, Field Engineer
Copperweld Steel Corporation
Glassport, Penna.

Willard deCamp Crater, Mgr. Vinyl Sales
Naugatuck Chemical Div.,
United States Rubber Co.
Naugatuck, Conn.

Charles M. Frederickson
Asst. Plant Superintendent
Kaiser Aluminum & Chemical Corp.,
Newark, Ohio

Hugo W. Biskeborn, Dir. of Mfg.
The Ansonia Wire & Cable Co.
Ansonia, Conn.

All wire mill men and wire mill suppliers are invited to attend this convention, see how the Association functions and participate in the activities.

Hotel reservations should be made by members of the Wire Association direct to the Secretary.
MAKE YOUR PLANS NOW TO ATTEND AND SEND YOUR RESERVATION PROMPTLY

MONDAY, NOVEMBER 14th

9:00 A.M.
REGISTRATION
ON MEZZANINE

10:00 A.M.
DIRECTOR'S MEETING
PARLOR E, MEZZANINE

12:30 P.M.
PROGRAM COMMITTEE LUNCHEON
PARLOR D

THE CONVENTION PROGRAM

LA SALLE HOTEL, CHICAGO, ILLINOIS, NOVEMBER 14-17, 1955

MONDAY, NOVEMBER 14th

9:00 A.M. Registration Desk opens on the mezzanine floor.

10:00 A.M. Annual Meeting of the Board of Directors of the Wire Association.

12:30 P.M. Directors' Luncheon for Program Participants. Address of Welcome by Leslie C. Whitney, President, The Wire Association.

AFTERNOON SESSION—2:00 P. M.

FERROUS SECTION

Symposium on Production Scheduling Based on Inventory Control

CHAIRMAN OF MEETING

John A. Moritz, Pres., Standard Industrial Compound Co., Chicago, Ill.

PANEL MEMBERS

John L. Sanderson, Supt., Wire Mills
Keystone Steel & Wire Co., Peoria, Ill.

L. W. Hackley, Dir.—Production Planning
American Steel & Wire Div., U. S. Steel Corp.
Cleveland, Ohio.

Tom M. Girdler, Jr., Asst. Division Mgr.
Union Drawn Steel Div., Republic Steel Corp.
Massillon, Ohio

C. M. Wilbur, Production Control Dept.
International Business Machines Corp., Endicott, N. Y.

A. C. Morse, Chicago Manager
Remington-Rand, Inc., Chicago, Ill.

AFTERNOON SESSION—1:30 P.M.

NON-FERROUS SECTION

CHAIRMAN OF MEETING

Charles M. Frederickson, Staff Devel. Eng., Kaiser Aluminum & Chemical Corp., Newark, Ohio

PAPER: "Progressive Work Hardening and Reannealing of Five Brands of High Conductivity Copper." — by M. V. Yokelson, Research Met. General Cable Corp., Bayonne, N. J. and M. Balicki, Prof., Met. Eng. Polytechnic Institute of Brooklyn

PAPER: "Effect of Cold Reduction on Some Properties of Nickel Wire" — by G. A. Nelson, Supervisor, Eng. Service Sylvania Electric Products, Inc., Warren, Pa.

PAPER: "Drawing and Processing of Titanium Wire" — by Douglas H. Wilson, Prod. Dept. Rem-Cru Titanium, Inc., Midland, Pa.

PAPER: "Ductility Tests for Electrical Conductors." — by Louis Boleraski, Research Engineer Kaiser Aluminum & Chemical Corp., Spokane, Wash.

PAPER: "Wax Lubricants in Non-Ferrous Wire Drawing." — by John Werner, Field Eng., Indus. Prod. Dept. S .C. Johnson & Son, Inc., Racine, Wis.

TUESDAY, NOVEMBER 15th

MORNING SESSION—9:30 A.M.

FERROUS SECTION

CHAIRMAN OF MEETING

Theodore B. Dull, Supt., Wire Mill, Sheffield Steel Div., Armco Steel Corp., Kansas City, Mo.

PAPER: "Continuous Gauging of Wire for Out of Roundness." — by Charles D. Gibbs, Sales Mgr. Industrial Gauges Corp., Englewood, N. J.

PAPER: "Advantages of Phosphating in Fastener Forming." — by John Geyer, Mgr. Development Div. and Hugh Gehman, Asst. Manager American Chemical Paint Co., Ambler, Pa.

PAPER: "New Type Plating Barrel for Automatic Handling of Large Batches." — by N. Ransohoff, Chairman of Board N. Ransohoff, Inc., Hamilton, Ohio

MORNING SESSION—9:00 A.M.

NON-FERROUS SECTION

CHAIRMAN OF MEETING

Willard de C. Crater, Mgr., Vinyl Sales, Naugatuck, Chemical Div., U. S. Rubber Co., Naugatuck, Conn.

PAPER: "The Treatment of Copper Conductors in High Velocity Recirculating Type Gas-Fired Ovens." — by Charles A. Windsor, Mgr. Wire Equipment Div. Michigan Oven Co., Detroit, Mich.

PAPER: "Solution Coating of Copper Wire." — by Cyril A. Litzler, Pres. C. A. Litzler Co., Cleveland, Ohio

PAPER: "Recent Developments in Polyethylene Insulating Materials." — by R. J. Lurie and J. A. Snyder, Development Engineers Bakelite Co., New York, N. Y.

PAPER: "Accelerated Heat Aging of Polyethylene" — by W. W. Spohn and S. P. Foster, Devel. & Service Sec. E. I. du Pont de Nemours & Co., Wilmington, Del.

TUESDAY, NOVEMBER 15th (cont'd)

AFTERNOON SESSION—2:00 P.M.

FERROUS SECTION

CHAIRMAN OF MEETING

Harry B. Matzen, Jr., Supt., Union Drawn Steel Div., Republic Steel Corp., Hartford, Conn.

PAPER: "Wire Descaling in Germany."	by Alfred O. Kogel, Mgr. Westfalische Drahtindustrie Westfalische, Germany
PAPER: "High Convection Annealing for Wire Coils."	by James L. Whitten, Vice. Pres. Lee Wilson Engineering Co. Cleveland, Ohio
PAPER: "Plastic Coating of Steel Wire."	by Joseph Beegle, Hauger—Beegle Associated, Inc. Chicago, Ill.

AFTERNOON SESSION—1:30 P.M.

NON-FERROUS SECTION

CHAIRMAN OF MEETING

Hugo W. Biskeborn, Director of Manufacturing, The Ansonia Wire & Cable Co., Ansonia, Conn.

PAPER: "Mineral Insulated Metallic Sheathed Cables."	by G. S. Eager Jr., Asst. Dir. of Res. and S. P. Lamberton, Research Supervisor General Cable Corp., Bayonne, N. J.
PAPER: "The Trend Toward Vinyl Insulation in Automotive Wiring Systems"	by R. H. Publow, Chief Chemist Essex Wire Corp., Detroit, Mich.
PAPER: "Maintenance and Repair of Signal Corps Wire Equipment."	by John A. Fitch, U.S.A. Signal Corps Philadelphia, Pa.
PAPER: "Reel Drive Selection."	by R. K. Larson, Systems Eng. Section, General Electric Co., Schenectady, N. Y.
MOTION PICTURE: "In the Chips."	Shown through the courtesy of Chase Brass and Copper Co., Waterbury, Conn.

WEDNESDAY, NOVEMBER 16th

MORNING SESSION—9:30 A.M.

FERROUS SECTION

CHAIRMAN OF MEETING

W. R. Cook, Supt., Wire Mill, Union Wire Rope Corp., Kansas City, Mo.

PAPER: "A Practical Psychological Approach to Quality Control."	by Glenn R. Lee, Supt., Wire Dept. Continental Steel Corp. Kokomo, Ind.
PAPER: "Factors Affecting the Characteristics of $Ca(OH)_2$ in Suspension, with Special Reference to the Wire Drawing Industry"	by Thomas C. Miller, Technical Director National Gypsum Co. Buffalo, N. Y.
PAPER: "Stress Corrosion and Relaxation of High Carbon Steel Wire for Prestressed Concrete."	by Dr. Fritz Schwier, Chief Eng. Felton & Guilleaume Carlswerk Koeln-Muelheim, Germany

MORNING SESSION—9:00 A.M.

NON-FERROUS SECTION

CHAIRMAN OF MEETING

Andrew Pudlak, Field Engineer, Copperweld Steel Co., Glassport, Pa.

PAPER: "Tin-Zinc Alloy Plating—Its Application to Copper Wire."	by F. A. Lowenheim, Supervisor, Electrochemical Research and R. T. Gore, Tech. Service Eng. Metal & Thermit Corp., Rahway, N. J.
PAPER: "Basic Principles of Continuous Wire Plating.	by A. B. Ashton, Research Manager, Frederick Smith & Co., Ltd. Manchester, England
PAPER: "Wire Die Shape and Finish; Some Recent Developments in Production and Inspection."	by E. J. Schneider, Vice Pres. Engis Equipment Co. Chicago, Ill.
PAPER: "Chrome Carbides for Hot Extrusion of Brass and Copper"	by A. Earle Glen, Mgr.—Die Sales Carboloy Dept., General Electric Co. Detroit, Mich.
MOTION PICTURE: "Nerves of the Nation."	Shown through the courtesy of Anaconda Wire & Cable Co., New York, N. Y.

WEDNESDAY, NOVEMBER 16th (cont'd)

AT 1:00 P.M. — THE ANNUAL WIRE ASSOCIATION LUNCHEON
(Held in the Century Room)

LADIES WELCOME LADIES WELCOME

THE PRESENTATION OF AWARDS FOR 1954

MEDAL AWARD: To Norman A. Wilson, Assistant Director of Research, Morgan Construction Co., Worcester, Mass., for his paper "The Cooling of Steel Wire During Continuous Wire Drawing."

CERTIFICATE OF HONORABLE MENTION: To Donald K. White, Foreman, No. 2 Wire Mill, John A. Roebling's Sons Corp., Trenton, N. J., for his paper "Continuous Patenting, Cleaning and Coating."

PRESENTATION OF TWENTY-FIVE YEAR CERTIFICATES by Leonard C. Crewe, Jr., Chairman, Board of Past Presidents.

THE MORDICA MEMORIAL LECTURE
"What Lies Ahead" by John H. Corson, Manager of the Laboratory,
The Carpenter Steel Company, Reading, Pa.

AT 4:00 P.M.—THE ANNUAL MEETING OF THE WIRE ASSOCIATION
This is the annual business meeting of members of the Association. Your personal attendance is needed and urged. Meeting in Parlor D.

Chairman of Meeting
Leslie C. Whitney, President
The Wire Association

IN THE EVENING BALLROOM, 19TH FLOOR

THE ANNUAL STAG SMOKER—DINNER

6:30 P.M.—Cocktail Bar Opens

7:30 P.M.—Dinner and Show

CHAIRMAN, ENTERTAINMENT COMMITTEE: Eber J. Hubbard, Jr.
COME ONE, COME ALL—AND HAVE A GOOD TIME!

THURSDAY, NOVEMBER 17th

The day is devoted entirely to the plant inspection tour of the Waukegan, Ill., plant of the American Steel & Wire Div. of the United States Steel Corp. to see the manufacture of steel wire.

The first bus leaves the LaSalle Hotel at 8 A.M. and the last bus leaves at 9 A.M.

All guests will be required to wear safety glasses and are asked to remain with the groups to which they are assigned. Glasses will be supplied at the plant.

Please go by bus. No one will be admitted to the plant after 10:30 A.M.

Luncheon may be obtained at several nearby restaurants after the tour. One bus will leave at 12 Noon and be back at the hotel by 1:30 P.M. Others will return to be back by 4 P. M.

BOTH FERROUS AND NON-FERROUS GROUPS ARE INVITED TO TAKE THIS TOUR

FOR THIS TOUR, ALL PERSONS MUST GO BY BUS. NO PRIVATE CARS MAY BE USED. TO BE ADMITTED, ALL VISITORS MUST WEAR THEIR BADGES; NO EXCEPTIONS, PLEASE. THESE MEASURES ARE FOR SECURITY AND SAFETY.

This plant inspection trip concludes the 1955 Convention.

RESEARCH PAPERS ARE PREPRINTED IN THE OCTOBER ISSUE OF WIRE AND WIRE PRODUCTS.

The Discussions and the Mordica Memorial Lecture will be printed in the January issue of Wire and Wire Products.

Papers not received in time for preprinting will be published in the November and December issues of Wire and Wire Products.

THE MORDICA MEMORIAL LECTURE

An invitation to deliver the Mordica Memorial Lecture is considered the highest honor within the power of the Board of Directors of The Wire Association to bestow upon a member.

The lecturer is selected each year by the Board of Past Presidents on the basis of outstanding contributions to the wire industry.

The lecture for 1955, entitled "What Lies Ahead" will be delivered by John H. Corson, Manager of the Laboratory, Carpenter Steel Co., Reading, Pa.

The Wire Association's
ANNUAL MEDAL AWARDS AND CERTIFICATES OF HONORABLE MENTION

All members of The Wire Association are cordially invited to submit technical papers either for publication in "WIRE & WIRE PRODUCTS" during the year or for presentation before the Annual Wire Association or the Regional Meetings.

Each year a medal will be awarded the paper selected as being the most meritorious one on wire manufacture or fabrication.

Honorable Mention Certificates are also awarded in the Non-Ferrous and Ferrous Divisions where such awards, in the opinion of the Awards Committee, are merited.

All papers submitted become the property of The Wire Association, and the Board of Directors constitutes the Committee on Awards.

Consideration for the Medal Award is not limited to the papers presented at the Meetings, but is given to all papers contributed by members and published in "WIRE & WIRE PRODUCTS" during the year.

THE TWENTY-FIVE YEAR CERTIFICATES

These certificates of The Wire Association are being awarded by the Board of Directors at the Annual Convention of The Wire Association to those who became members of our society in 1931 and who have been members continuously since that time. These persons are:

COL. GEORGE P. BUSH, U.S.A. (Ret.)
HUGH B. CARNAHAN
HERBERT B. CLARK
JOHN HUYLER DeKLYN
EDWARD FRANCIS EARLY
FLINT C. ELDER
HENRY M. HEYN
CARL WALTER HOLMQUIST
JAMES KENNETH MacDOUGALL
ARTHUR G. MADISON
PAUL A. NEHRING
RAYMOND SAMUEL SIMMONS
EARL H. THOMAS
FREDERICK A. WESTPHAL

WIRE and WIRE PRODUCTS

reaches many prospects

YOUR SALESMEN DON'T KNOW!

No matter how big you are, the odds are you don't know all your actual prospective customers.

If your company is small, it is even more important to be "calling" on your prospects and customers regularly through advertising.

Your advertising in Wire and Wire Products will be seen by many people in the plants you wish to "sell" whom your salesmen never would see, yet who specify, actually buy or who influence decisions on products to be purchased. Your advertising is bound to be of immeasurable value to you, too, in paving the way for a good reception for your salesmen when they do call. And the field's buying power is tremendous!

WIRE AND WIRE PRODUCTS circulation, is all paid. We have no agents, offer no premiums or make special inducements to get circulation, except the value of the editorial contents in itself—yet our renewals have averaged 97% or better for many years. That's why it is a good and forceful advertising medium for all concerns who have products to sell to the wire industry.

- **GET YOUR SHARE OF THE BUSINESS . . .**
- **ADVERTISE IN WIRE AND WIRE PRODUCTS . . .**
- **SEND FOR ADVERTISING RATES TODAY . . .**

WIRE AND WIRE PRODUCTS

453 MAIN STREET **STAMFORD, CONN.**

Government Wire Production Information

Announcement of New Publication

Units of Weight and Measure—Definitions and Tables of Equivalents, by **Dr. L. V. Judson, National Bureau of Standards** Miscellaneous Publication 214, 64 pages, 40 cents. (Order from the Government Printing Office, Washington 25, D. C.).

★ ★ ★

This publication, superseding Miscellaneous Publication 121 issued in 1936, defines the units of length, mass, area, volume, and capacity in use in the United States. It also gives tables of interrelation and tables of equivalents for these units in the metric system and in the U. S. customary system.

★ ★ ★

In addition, the volume contains sections of the fundamental equivalents, the approved spelling and abbreviation of each of the most common units of weight and measure, and the status of the metric system in the United States. All of the tables and other material have been revised to conform to current definitions, equivalents, and usages. Conversion tables are confined to simple units, excluding all compound units such as foot-pounds, pounds per cubic foot, and feet per second.

★ ★ ★

For this revision, tabular values involving the liter have been changed to the basis 1 liter=1.000,-028 cubic decimeters and the international nautical mile of 1,852 meters, as adopted by the Departments of Defense and Commerce on July 1, 1954, has been substituted for the U. S. nautical mile. The publication should prove useful in scientific, industrial, commercial, and other fields.

(NOTE: Foreign remittances must be in U. S. exchange and should include an additional one-third of the publication price to cover mailing costs).

Appointed Deputy Commissioner Emergency Procurement Service

Appointment of **Russell A. Heddleston** as Deputy Commissioner, Emergency Procurement Service has been announced by **Edmund F. Mansure, Administrator of General Services.**

★ ★ ★

Mr. Heddleston will serve as the deputy for Commissioner **A. J. Walsh** who heads Emergency Procurement. It is the GSA Service which buys and stores items for the national stockpile of strategic and critical materials. It also engages in special programs under the Defense Production Act.

★ ★ ★

Mr. Heddleston has had wide Government experience and recently concluded a tour of duty as As-

CAMDEN WIRE CO., INC.

Wire Fabricators

Producers of Quality Fine Wire Copper Conductors

EXTRA FLEXIBLE CONDUCTOR STRANDED OR BRAIDED

MULTIPLE ENDS OF SIZES .008 to .002

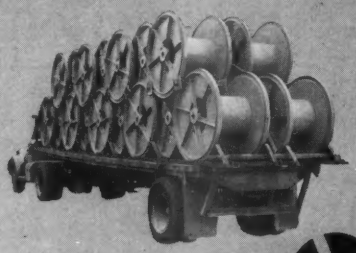
BARE • TIN or LEAD COATED • SILVER PLATED

Special Heavy Tinned Conductors for Hook-up Wire

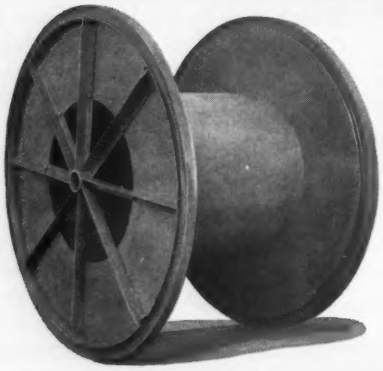
40 MASONIC AVENUE • CAMDEN, NEW YORK

There's no premium on INGENUITY at NYECO

Here are 32 Steel Shipping Reels being delivered on 1 especially rigged truck. One more example of the versatility and flexibility that go into every NYECO job . . . that make for happy customer relationships.



NYECO Steel Shipping Reels



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because they cost so little more, last *12 times* longer than wooden reels, require minimum maintenance. Rugged weatherproof, splinter-proof, warp-proof construction protects costly cable against damage due to dropping, bouncing, rough handling. It doesn't pay to risk an investment of thousands on inferior reels.

ANY QUANTITY | ANY SIZE | ANY LOAD | FLANGE DIAMETER FROM 36" UP

SERVICE IS OUR BUSINESS: Qualified engineering staff will translate your problems into practical designs, from idea to finished product—or we'll work from your blueprints. 2 large modern plants with every automatic production facility, 100 in skilled personnel. Fast deliveries—motor, rail, water shipping at the premises.

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These leading mills prefer NYECO Steel Reels: OKONITE, ROEBLING, WESTERN ELECTRIC, GENERAL CABLE, ANACONDA, PHELPS DODGE

sistant to a Commissioner, Commission on Organization of the Executive Branch of the Government (Second Hoover Commission).

★ ★ ★

From February to October, 1953 he was Executive Assistant, Office of Defense Mobilization and for two years prior to that was Executive Assistant to the Administrator, Defense Production Administration. From 1950 to 1951, Mr. Heddleston was Staff Director of the Williams Subcommittee, Committee on Post Office and Civil Service of the House of Representatives. During the period October 1947 through August of 1949 he served as Assistant to a Commissioner of the First Hoover Commission.

★ ★ ★

He has also served the Government as Director, Education Division, Office of Aircraft and Electronics both in the Reconstruction Finance Corporation and the War Assets Administration.

★ ★ ★

During World War II he was with the Army Air Forces, Supply Division, Air Service Command, Wright-Patterson Field, Dayton, Ohio. He was educated at Ohio State University, Geneva College, and the Graduate School of the University of Pittsburgh.

Government Purchases

Quantities bought through June 30, 1955 under the Government's purchase programs for domestic tungsten, manganese, chrome, mica, beryl, asbestos and columbium-tantalum have been announced by **Edmund F. Mansure,** Administrator of General Services.

★ ★ ★

The programs were established to stimulate the search for and the production of strategic and critical materials in the United States. They are separate from the exploration program of the Defense Minerals Exploration Administration, Department of the Interior.

★ ★ ★

Tungsten. Tungsten concentrates under the Government purchase

program are accepted at various milling points, mostly in the West. The regulation setting up the tungsten purchase program was published in the Federal Register on May 11, 1951. Purchase of 3,000,000 short ton units (20 pounds each) of contained tungsten has been authorized. Delivered to date: 1,930,028 short ton units.

★ ★ ★

Manganese. Manganese is accepted at three depots—Butte and Philipsburg, Montana; and Deming, New Mexico. Manganese is also accepted in carload lots at any rail point in the country. A depot at Wenden, Arizona has been closed after acquiring its goal.

★ ★ ★

Regulations establishing the Butte, Philipsburg and Deming depots were published July 21, 1951; the Wenden regulation was published July 3, 1952, and the carload regulation on July 9, 1952. The quantities authorized are: 6,000,000 long ton units (22.4 pounds each) of contained manganese for Butte and Philipsburg together; 6,000,000 long ton units for Deming; 6,000,000 long ton units for Wenden, and 19,000,000 long ton units for the carload program. Delivered to date: Butte and Philipsburg, 1,728,001 units; Deming, 3,250,174 units; Wenden, 6,108,316 units; carload program 3,642,084 units.

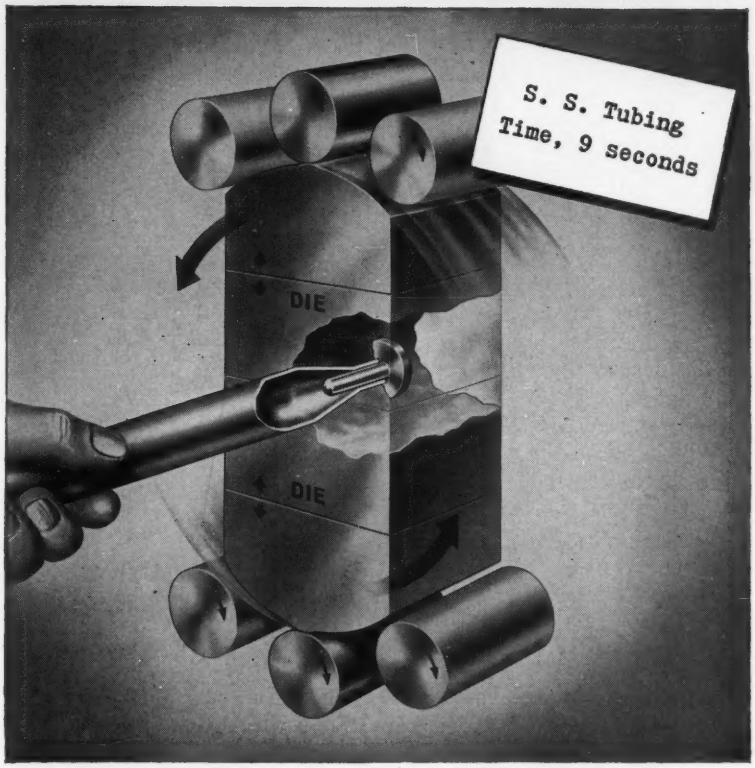
★ ★ ★

Chrome. Chrome ores and concentrates are accepted at a depot at Grants Pass, Oregon. The program was published August 28, 1951. Purchase of 200,000 long tons of ores and concentrates has been authorized. Delivered to date: 87,833 long tons.

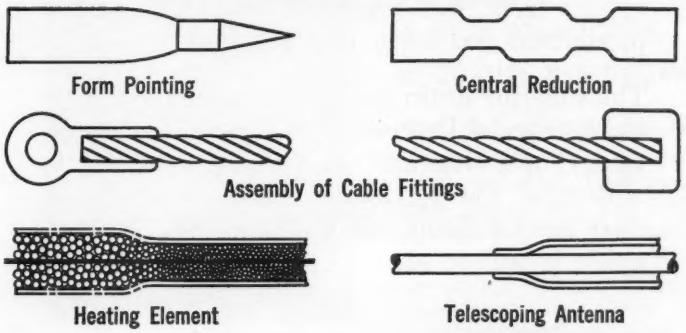
★ ★ ★

Mica. Mica is accepted at three depots—Spruce Pine, North Carolina; Custer, South Dakota, and Franklin, New Hampshire. It is accepted in three forms—block, film and hand-cobbed. Under a revision of the program announced July 23, 1954 the depots now will accept nonruby mica, subject to electrical tests, as well as ruby mica. The program was published

GET MORE PARTS
Instead of chips and scrap
with ROTARY SWAGING



OTHER SWAGING EXAMPLES:



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PRECISION ROLLING MILLS—TURKS HEADS—WIRE SHAPING MILLS—SWAGING MACHINES—ACCESSORIES

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Due to the unusual deep socket in the above Adjusting Screw it could not be formed from regular annealed and processed cold heading wire.

Keystone's metallurgist recommended Keystone "Special Processed" wire. The manufacturer has now standardized on "Special Processed" wire for this and other difficult cold headed parts. His results have been improved quality, increased production and lower cost per unit.

The superior grain flow characteristics of Keystone "Special Processed" wire provide the necessary upsetting and die forming qualities to withstand the terrific metal displacement in your most difficult cold heading jobs. Your inquiry is welcomed.

March 15, 1952. Purchase of 25,000 short tons of hand-cobbed mica or the equivalent has been authorized. (For purposes of the program, 90 pounds of block or film mica are considered as the equivalent of one ton of hand-cobbed mica.) Delivered to date: 6,285 tons of all types at all depots.

★ ★ ★

Asbestos. Nonferrous crysotile asbestos in three grades, Crude Nos. 1, 2 and 3, is accepted at a depot at Globe, Arizona. Purchase of 1,500 short tons of Crude No. 1 and/or No. 2 has been authorized. Crude No. 3, which is accepted on a tie-in basis with the other two grades, is not figured into the quantity authorized. Delivered to date: Crude No. 1 and No. 2, 963 short tons; Crude No. 3, 456 short tons. Total, in terms of program, 963 tons Crude Nos. 1 and 2.

★ ★ ★

Columbium-Tantalum. Regulation covering the columbium-tantalum program was first published October 30, 1952. Under it, columbium tantalum ores and concentrates were accepted in small lots at three depots—Custer, South Dakota; Franklin, New Hampshire and Spruce Pine, North Carolina. No specific limits were set for the depots. Columbium and tantalum were purchased from both domestic and foreign sources through four agents—Fansteel Metallurgical Corporation, North Chicago, Ill.; Wah Chang Corporation, New York, N. Y.; Kennametal, Inc., Latrobe, Pennsylvania, and Emergency Procurement Service, GSA, Washington, D. C. Purchase of 15,000,000 pounds of contained combined columbium-tantalum pentoxide was authorized. On June 30, 1955, deliveries stood at 11,842,162 pounds. However, forward foreign commitments has caused the program limitation to be exceeded and no further purchases of foreign ore or concentrates are being made.

TO SELL—ADVERTISE IN
WIRE AND WIRE PRODUCTS
It pays—send for rates
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ABSTRACTS

DUCTILITY OF VACUUM HEAT-TREATED MOLYBDENUM WIRES
W. E. Few, G. K. Manning. Journ Met: Trans Sect 1955 Vol 7 (2) pp 343-344; Engg Index Service 55-11337, 127-221
Effect of heating rate and time at 3,800 deg F (2,093 deg C) on tensile properties of molybdenum wire; reversibility of heating rate effect; effect of rapidly heating to intermediate temp then slowly heating to 3,800 deg F; effect of interrupting cooling of wires heated to this temp.

★ ★ ★

THE MEASUREMENT OF THE CIRCULARITY OF ELECTRIC (CONDUCTING) WIRE DRAWING DIAMOND DIES
T. Hisamoto, K. Kakizaki (Hitachi Electr Wire Works Ltd.) Hitachi Hyoron 1953 Vol 35 (8) pp 1235-1241 (In Japanese)
Method for accurate measurement of wire drawing die channels developed, and with this measurements carried out to determine standard for roundness of die bores. Preliminary tests made relating shape of die channel and wear, in order to increase wear resistance of diamond dies. Found that accuracy of roundness of finished diamond hole is about ± 0.5 micron. Wear of diamond dies characterized by wear being non-uniform over periphery of hole but symmetrical to centre of true circle. [English translation of this paper will be published in due course—Ed]. 9 illustr, 14 ref, 3 tables.

★ ★ ★

THE EFFECT OF PLASTIC DEFORMATION ON THE SURFACE RESISTIVITY OF COPPER WIRES
J. Aron, D. Kahn (Lewis Flight Propulsion Lab). Phys Rev 1955 Vol 98 (1) p 246 (Apr 1)
Abstr of paper to Am Phys Soc mtg, Nov 26-27, 1954. Change in surface resistivity of 0.05 cm copper wire after 10-15% elongation measured.

★ ★ ★

THE PREPARATION OF DIE TOOLS
T. Kalán. Kohászati Lapok (Journ Metall) 1954 Vol 9 (9) pp 390-397 (Sep); noted Hungar Techn Abstr 1955 Vol 7 (1) p 34 (Original in Hungarian)

★ ★ ★

METHOD OF INTRODUCING FINE WIRES INTO THICK-LAYERED PHOTOGRAPHIC PLATES
O. N. Miller, A. A. Sirotinskaya (Moscow State Univ). Zhurn Eksp i Teoret Fiz 1953 Vol 24 pp 237-239; Chem Abstr 1955 Vol 49 (10) col 6738 (May 25) (Original in Russian)

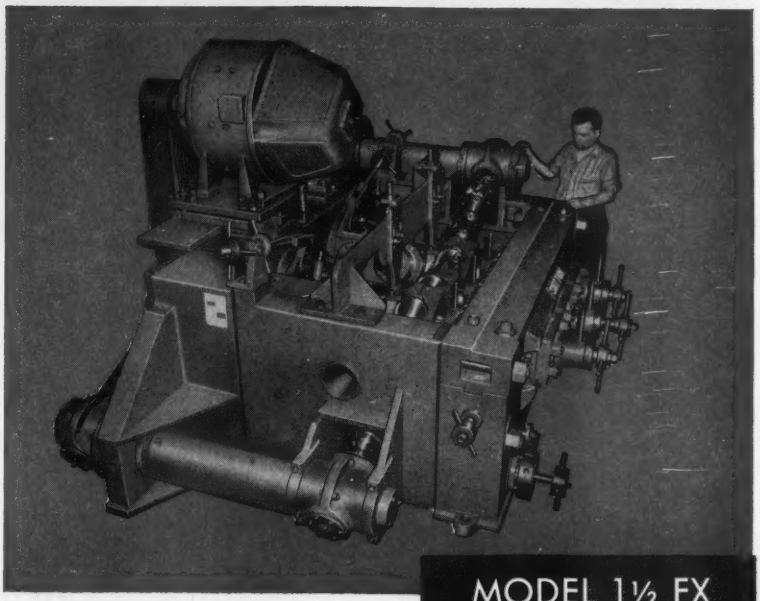
★ ★ ★

IMPROVEMENTS IN METHOD AND EQUIPMENT FOR DRAWING QUARTZ FIBERS
R. G. Olt. Mound Lab Contract AT-33-GEN-53 (MLM-656) 1952 23 pp (Jan 29); Nuclear Sci Abstr 1955 Vol 9 (5) pp 191-192 (Mar 15)

★ ★ ★

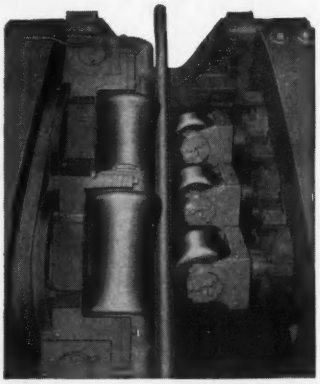
INVESTIGATION OF RHENIUM. QUARTERLY PROGRESS REPORT NO 7 FOR THE PERIOD DECEMBER 23, 1953 TO MARCH 22, 1954
C. T. Sims & coll. Battelle Mem Inst

HIGH SPEED SUTTON 5-Roll
STRAIGHTENER AND POLISHER



MODEL 1½ FX
(Pictured)
BARS from 5/16" to 2½" Dia.
TUBES from 5/16" O.D. to 3" O.D.
OTHER SIZES AVAILABLE

FOR FAST AND ACCURATE STRAIGHTENING AND POLISHING OF COLD DRAWN ROUND BARS AND TUBES



- DEPENDABLE SERVICE
- HIGH PRODUCTION
- QUALITY PERFORMANCE

This Sutton model shows the flexibility of the 5-roll principle illustrated at left. While normally only two of the five rolls are driven, this machine has four driven rolls to provide a burnishing action which polishes as it straightens.

Ask for Bulletin No. 25

SUTTON Engineering COMPANY
Manufacturers for Ferrous and Non-Ferrous Metal Industries
STRAIGHTENERS, EXTRUSION PRESSES, HYDRAULIC STRETCHERS, SHEET LEVELERS, CONTOUR CORRECTING MACHINES, STRAIGHTENING PRESSES, ROTARY CLEANERS, HEAVY-DUTY UNIVERSAL JOINTS, ROLLS
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PHONE: GRANT 1-8077 PLANT: BELLEFONTE, PA.

AD-33442 Contract AF-33(616)-232 1954 67 pp (Mar 22); Nuclear Sci Abstr 1955 Vol 9 (8) p 353 (Apr 30)
Fabrication of fine wire and thin sheet by swaging, round wire drawing, Turk's head wire drawing, and rolling discussed.

★ ★ ★

THE ACTIVITIES OF THE VEREIN DEUTSCHER EISENHEUTTENLEUTE IN 1954. AUS DER TAETIGKEIT DES VEREINS DEUTSCHER EISENHUETTENLEUTE IM JAHRE 1954
Anon. Stahl & Eisen 1955 Vol 75 (13) pp 821-850 (June 30) (In German)
Survey. Activities of Comm for Wire Working continued. Investigations on shape of drawing dies and their durability. Temp in drawing die during wire drawing investigated and improved instruments for measuring bearing length developed. 1 illustr, 215 ref, 4 tables.

★ ★ ★

USP 2,699,518. GRID WIRE FOR ELECTRON TUBES
Chem Abstr 1955 Vol 49 (7) col 4414 (Apr 10)
Alloy of 90-95% Pt, 5-10% Ru, used as grid wire for subminiature tubes; drawn, with annealing, from ingot produced by melting appropriate amounts of each metal. Wire of high tensile strength results.

These abstracts are published through the courtesy and with the permission of the Industrial Diamond Research Bureau, 34, Holborn Viaduct, London, E.C.1, England. Inquiries regarding them should be directed to the Bureau.

Wire Drawing Begins for Straits of Mackinac Bridge Cables

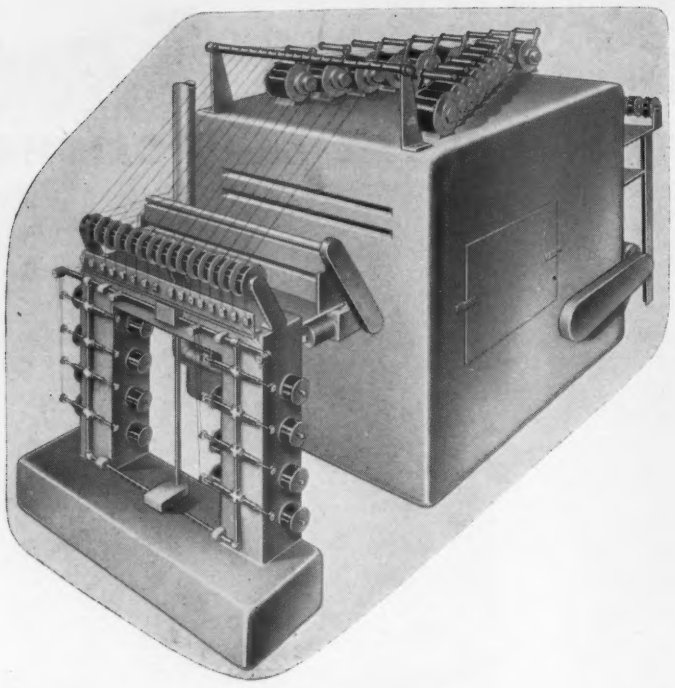
Wire drawing operations for the cables of the 3,800 ft. suspension type center span of the Straits of Mackinac bridge have begun at the Trenton Works of the **American Steel & Wire Division** of **United States Steel Corp.** These suspension cables, which total 12,000 tons of wire, comprise two separate 24 inch main cables weighing approximately 12 million pounds each.

★ ★ ★

Wire drawing is being handled on a Vaughn 6 Spindle Wire Block Machine with Wire Block Motor Controller, Automatic Synchronous Motor Starter, and Circuit Breaker Panel specially designed and built by **The Electric Controller & Manufacturing Company,** Cleveland, Ohio. The machine with these controls permits wire to be drawn from approximately .350″ down to .196″ at speeds up to 700 feet per minute.

★ ★ ★

When completed, each 24-inch suspension cable will consist of 12,920 strands of .196″ galvanized



After Years of Research . . . A New Fine Wire Enameling Oven to Cut Costs, Increase Production

Obsolete or inefficient magnet wire processing equipment can mean a substantial loss in your production operation. That's why wire manufacturers all over the country are searching for improved methods of cutting costs. Many are focusing their attention on wire enameling machines—and finding the answer.

This new MOCO Fine Wire Enameling equipment combines sound engineering principles with years of "know-how". It is competitively priced, economical in operation, versatile and simple. The high degree of skill formerly required in performing this operation has been reduced—control of the product is handled by the machine.

YOU GET ALL THESE NEW FEATURES

- Advanced design, offering low fuel consumption—less maintenance costs.
- Increased enameling speeds—with minimum wire breakage.
- A wide range of insulating materials may be handled.
- New rapid start-and-stop device increases production.

MOCO's entire engineering, service, and sales staff have one interest—your heat processing operation. Why not contact your MOCO representative today.

PRODUCERS OF COMPLETE ENAMELING SYSTEMS FOR ALL WIRE SIZES.

The story of MOCO's new wire processing oven is presented in this folder—write today.

MICHIGAN OVEN COMPANY DETROIT MICHIGAN MOCO

MICHIGAN OVEN COMPANY
425 BRAINARD ST., DETROIT 1, MICHIGAN

high tensile bridge wire, wrapped with a thread-layed cover of lower tensile galvanized wire.

1955 BISRA Survey

The contents include news of developments from several of the Association's Divisions and Departments. BISRA's technical services, which have increased steadily in range and effectiveness over recent years, are also described in some detail.

★ ★ ★

The article on the furnace-scanning periscope (page 5) gives details of an instrument which should prove of value wherever furnaces are used, making it possible to study firing and melting conditions in furnaces at any stage of operation.

★ ★ ★

Page 11 describes an adaptation of the familiar teleprinter apparatus for industrial purposes. This development suggests that the teleprinter has many uses as a control and research tool, making possible a much greater use of works records by its speed and economy, both in collecting and subsequently analyzing operational data.

★ ★ ★

On page 14 is an illustrated article on better lubrication in wet wire drawing. A new design for a soap nozzle is described and the results of tests given.

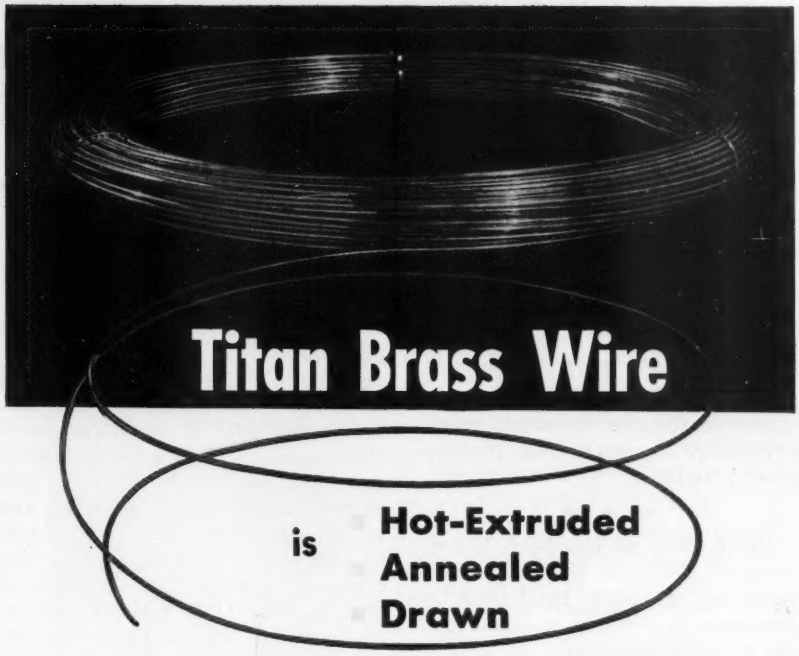
★ ★ ★

For further information, please address the **British Iron & Steel Research Association,** 11, Park Lane, London W. 1, England.

Improvement in Chain Link Machine Saves Wire

The line of "Invincible" chain link fencing machines manufactured by **Arthur Blashill & Co.,** 78 Downing Street, Worcester 10, Mass., now incorporates the new "Applicator", which uses a well-supported, but $\frac{1}{8}$ in. thinner blade. This is claimed to give a saving of over $\frac{3}{4}$ in. of wire for each revolution of the blade.

★ ★ ★



for highest strength and quality

Titan Brass Wire has precisely uniform gauge . . . color . . . texture . . . temper . . . is free from physical defects. For making highest-quality rivets, bolts, nuts, eyelets, fasteners, screws, studs, binding posts, terminals, washers, pins and nails . . . order Titan Brass Wire. Compositions and tempers are supplied to meet every requirement. Let us help you choose the proper wire composition and temper for **Heading & Extruding**
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Offices and Agencies in these cities:

Atlanta	Denver	New Orleans	Seattle
Camden	Detroit	New York	St. Louis
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Cleveland	Los Angeles	San Francisco	Washington

Mill Depots: Bellefonte, Pa., and Indianapolis

Write today for free folder "Titan Brass Wire" listing grain sizes, weights, tolerances and other data. Address: Customer Service Division, Titan Metal Mfg. Co., Bellefonte, Pa.

Titan®

METAL MANUFACTURING COMPANY

General Offices & Plants: Bellefonte, Pa.

Quality Alloys by Brass Specialists

Outstanding Personalities of the Wire Industry

To Handle Production for Minnesota Mining

Promotion of **Donald R. Guthrie** to general manufacturing manager of the coated abrasives and related products division has been announced by **Minnesota Mining & Manufacturing Co.**

★ ★ ★

In this position he will be responsible for the division's manufacturing, research and development programs.

★ ★ ★

Since 1953 he has been the division's assistant general manufacturing manager. He joined the company in 1939 as a chemist in the research laboratory. In 1942 he was transferred to the engineering department where he held the positions of division engineer, color and chemical division; head of the chemical engineering department; division engineer of staff laboratories and executive engineer of engineering research. He graduated from the University of Iowa in 1938 with a B. S. degree in chemical engineering.

Named President Bristol Brass

Joseph O'Brien was elected president of the **Bristol Brass Corporation** at a meeting of the board of directors in Bristol in August. He moved up from the position of vice president and general superintendent to fill the position left vacant when **Roger E. Gay** was given a leave of absence in April to undertake a special assignment in the Department of Defense in Washington. **Otto Von Au,** former president of Bristol Brass' wholly owned subsidiary the **Accurate Brass Corporation** was elected vice president.

★ ★ ★

Mr. O'Brien culminates 38 years with the company by his election as president. Before he became vice president and general superintendent in 1952 he had been vice president in charge of sales, sales manager and assistant sales manager.

Named General Superintendent of Bristol Brass

Joseph T. Hassett has been appointed General Superintendent of The Bristol Brass Corporation, it was announced today by **Joseph O'Brien,** president.

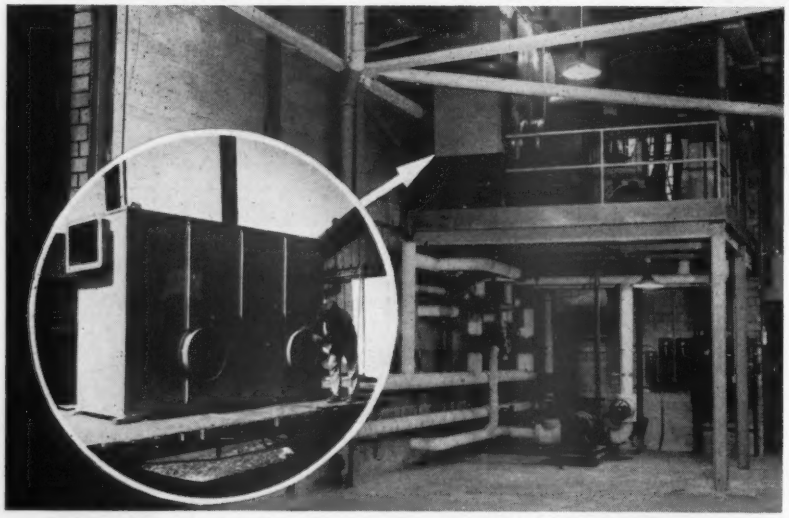
★ ★ ★

Mr. Hassett has been assistant general superintendent since 1953, moving up from his position as head of Time Study and Methods Department.

★ ★ ★

He began work at Bristol Brass in 1939.

FOR CONTROLLING ACID FUMES IN YOUR PICKLING OPERATIONS



Rigidon duct system installed in new wire mill to handle sulfuric pickling fumes. (Engineered by Austin Company, Cleveland, Ohio).

SPECIFY RIGIDON SOLID PLASTICS

- √ **Acid protection inside and out**
- √ **Round or rectangular**
- √ **Easy to install**
- √ **Low initial cost**
- √ **Good chemical resistance**

CHEMICAL-PROOF LININGS-TANKS HEATERS PLASTICS

HEIL PROCESS EQUIPMENT CORPORATION

12901 Elmwood Avenue • Cleveland 11, Ohio

Other Heil Products Include:

COATED AND LINED FANS • PICKLING TANKS • NOCORDAL IMPERVIOUS GRAPHITE EXTERNAL HEAT EXCHANGERS • MONEL PICKLE HOOKS • LEAD STEAM JET AGITATORS • ACID PROOF MAINTENANCE MATERIALS FOR EXTERIOR APPLICATIONS • SPECIAL LEAD FABRICATIONS.

Lachmann Joins U. S. Industrial Chemical Co.

John Lachmann, who has been identified with the plastics industry since 1945 as a technical specialist for extrusion problems and wire covering with plastic materials, has joined the staff of **U. S. Industrial Chemicals Co., Division of National Distillers Products Corp.,** 99 Park Ave., New York 16, N. Y., to work on "PETROTHENE" Polyethylene Resins, it was announced in August by **Lee A. Keane,** U. S. I. Vice President and Director of Chemical Sales.

★ ★ ★

Mr. Lachmann, who reports to **Vincent McCarthy,** Sales Manager of "PETROTHENE" Polyethylene Resins for U. S. I., will devote his initial efforts to sales service in the field of wire covering with plastic materials.

★ ★ ★

A graduate of Rensselaer Polytechnic Institute, Mr. Lachmann comes to U. S. I. from the **Chester Cable Corp.,** Chester, N. Y. He was previously with the Polychemicals Department of **E. I. du-Pont de Nemours & Co.** His experience was in sales service work on polyethylene, with particular emphasis on the electrical insulation materials used by the wire and cable industries.

John Lachmann

Federal Wire & Cable Elects New Vice President and Manager

President J. G. Smith of **Federal Wire & Cable Ltd.,** Guelph, Canada, announces the appointment of **Gordon D. Tiller** as vice president and general manager, effective September 15, 1955. He has been with the company for 15 years and has been comptroller since 1950.

★ ★ ★

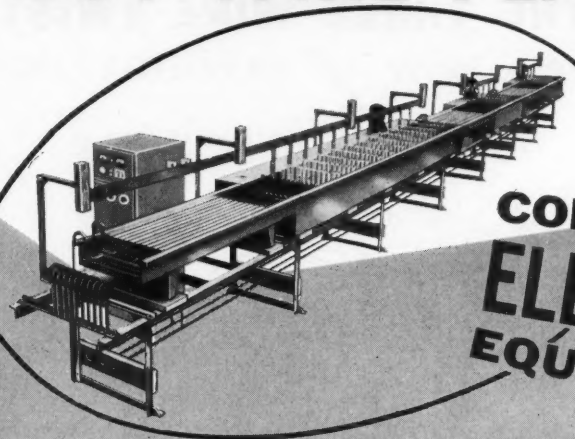
Appointed to the board of directors is **T. G. Bell,** who has resigned as vice president and general manager, and who becomes a director and executive vice president of **Fiberglass Canada Ltd.**

Carboloy Appoints Product Development Engineer

C. S. Wiedman, product and process development engineer, **Carboloy Department of General Electric Company,** Detroit, has been appointed manager of carbide products development engineering. In his new post, he will be responsible for directing the metallurgical

CUT WIRE PLATING COST!

maintain uniformity on copper and aluminum wire



CONTINUOUS U.I.E.C. ELECTROPLATING EQUIPMENT

This low cost equipment performs uniform high quality work at speeds that mean real savings. Simple to operate. We furnish complete installation.

Write today to:

UNIVERSAL INDUSTRIAL EQUIPMENT CO.

SECAUCUS, NEW JERSEY

development of carbide materials and related processes.

★ ★ ★

A native of Buffalo, N. Y., he joined General Electric Company in 1947, completing the company's chemical and metallurgical training program in 1948. He joined Carboloy Department shortly thereafter. He holds a Bachelor of Science degree in metallurgical engineering from the University of Michigan.

Elected Chairman and President of Westinghouse

Gwilym A. Price, president of the Westinghouse Electric Corporation since January, 1946, was elected chairman and president, at the meeting on August 24 in New York City, of the Board of Directors. Mr. Price continues as chief executive officer, a responsibility he has carried throughout his term as president. The board chairmanship at Westinghouse has not been occupied since 1951.

★ ★ ★

The directors elected **Mark W. Cresap, Jr.,** to serve as executive vice-president and deputy chief executive officer. Since April, 1951, Mr. Cresap has been vice-president and assistant to the president of Westinghouse.

★ ★ ★

Latham E. Osborne, whose 45-year career at Westinghouse has covered all the distance between a tool clerk's job and the executive vice presidency, was elected vice-chairman of the board.

★ ★ ★

John K. Hodnette, formerly vice-president in charge of the Company's apparatus products divisions, was elected vice president-general manager, responsible for supervision of the operations of all of the Company's product groups. He also was elected to the Board.

★ ★ ★

The position left vacant by Mr. Hodnette was filled by the appointment of **A. C. Monteith,** since 1948 the Company's vice-president in charge of engineering and research. Succeeding Mr. Monteith in that post is **Dr. John A. Hutcheson,** director of the Westinghouse Research Laboratories since 1949, and a vice-president since 1950.

Reliance Electric Appointments

Appointment of **Hamilton F. Biggar, Jr.** as Manager of New Product Development at the **Reliance Electric & Engineering Company,** Cleveland, Ohio, has been announced by **W. R. Hough,** Vice President of Engineering and Control Manufacturing, combining, with the Atomic Power Motor Development activity, which Mr. Biggar has been managing, the Research and Technical Services of the Engineering Department. **Robert R. Hayes** has been appointed Supervisor of the Atomic Power Development.

★ ★ ★

A new assignment in the sales organization has been the appointment of **Donald C. Obermeyer** as a sales engineer in the company's

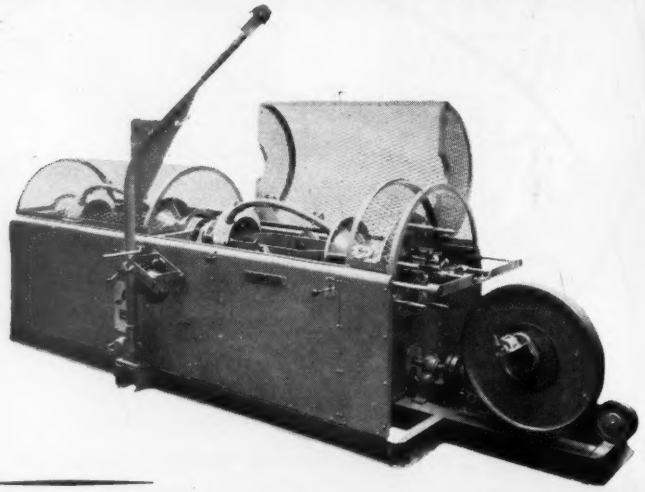
After The Twinner,

. . . THE THREE WIRE TWISTER

PRODUCTIVE:
300 to 1000 r.p.m. reels:
let-off: 18" and 24" diameters
single or dual take-up:
up to 42"

SURE:
—adjustable tension
—convenient for fine copper wires (26 AWG)
—each reel on ball bearings
—dual drive
—minimum lay 3/4"
—spark tester
—automatic stop motion
—crane for loading

FLOOR SPACE REDUCED:
18" type: length = 12'



POURTIER MACHINES

153, rue Général Gallieni

ROMAINVILLE (Seine) **FRANCE**

Minneapolis Branch Office, was also announced by **C. V. Gregory,** Manager of District Sales.

R B & W Names New Plant Managers

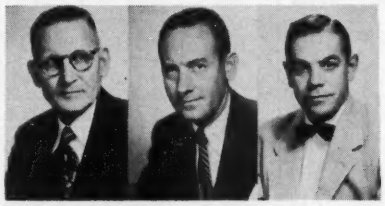
New plant managers have been appointed at **Russell, Burdsall & Ward Bolt and Nut Company** plants in Coraopolis, Pa. and Rock Falls, Ill., according to an announcement by **William E. Ward,** president and general manager of the 110-year old fasteners firm.

★ ★ ★

Lambert M. Kaspers, plant manager at Coraopolis since 1952, will manage the Rock Falls plant. He succeeds **William H. Hoofstitler,** who is retiring after 46 years of continuous service with R B & W. Mr. Kaspers, a graduate of the University of Rochester and Harvard Business School, joined R B & W in 1940. He has been engaged in various production and plant management capacities in both Coraopolis and Rock Falls, except for three years service with the Navy.

★ ★ ★

Robert J. McCombs will be new plant manager at Coraopolis. Plant superintendent since 1952, Mr. McCombs joined R B & W in 1948 as machine shop and tool room foreman after graduation from Carnegie Institute of Technology.



William C. McIlvain, Robert J. McCombs, Lambert M. Kaspers

William C. McIlvain will succeed Mr. McCombs as plant superintendent at Coraopolis. A twenty-year veteran with R B & W, Mr. McIlvain has previously headed up such departments as plant maintenance, cold nut punching and slotting.

Millard Named Sales Manager by Carpenter-Webb Wire

William A. Millard has been appointed sales manager of the **Webb Wire Division, The Carpenter Steel Company,** New Brunswick, N. J. As such, he will maintain headquarters in the home office and direct the company's sales efforts all over the nation.

★ ★ ★

Mr. Millard has been with the Webb Wire Division in a sales capacity since March 1953. Before that he was associated with the parent Carpenter organization as a sales engineer in southeastern Pennsylvania.

★ ★ ★

He started his career in the steel industry in The Carpenter Steel Company's Reading, Pa., sales office in 1941. After four years active duty with the U. S. Army infantry in Europe, Africa and the South Pacific, he returned to Carpenter to resume his sales activities.

(*Please turn to page* 1288)

NESOR ALLOY PRODUCTS CO.

MANUFACTURERS OF WIRE • STRIP • BRAID • STRAND

282 HALSEY STREET NEWARK, N. J.

FINE WIRE

TO .001

IN THE FOLLOWING METALS AND ALLOYS

ALUMINUM- AND ALLOYS	MONEL-NICKEL	COPPERCOATED STEEL
BARE AND TINNED COPPER	STAINLESS STEEL	SILVER PLATED COPPER
LEAD AND SOLDER ALLOYS	STEEL-LOW AND HIGH CARBON	BRASS AND ALLOYS
PRECIOUS METALS	RESISTANCE WIRE	PHOSPHOR BRONZE

Exacting size tolerances—uniformity of tempers, a good product and prompt service. A dependable supplier soliciting your business.

Consultation—Samples and Quotations Without Obligation.

AMERICAN IRON AND STEEL INSTITUTE

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AIS 10

Total Number of Companies Included 134

JULY - 1955
Month

SHIPMENTS OF STEEL PRODUCTS
ALL GRADES INCLUDING CARBON, ALLOY AND STAINLESS
(Net Tons)

Covering Net Shipments (Excluding Shipments to Members of the Industry for Conversion into Further Finished Products or for Resale)

Steel Products	Items	Current Month 1955 Carbon	Alloy	Stainless	Total	Percent of Total Shipments	Prior Year (1954) Percent of Total Shipments	Year to Date 1955 Carbon	Alloy	Stainless	Total	Percent of Total Shipments	Prior Year (1954) Percent of Total Shipments
Ingots	1A	35,946	12,311	1,228	49,485	0.8	0.6	214,550	97,850	15,741	328,141	0.7	0.5
Blooms, slabs, billets, tube rounds, sheet bars, etc.	1B	170,562	42,023	1,477	214,062	3.4	2.0	1,302,596	307,349	10,456	1,620,401	3.3	2.3
Skelp	2	13,461	-	-	13,461	0.2	0.2	98,888	-	-	98,888	0.2	0.2
Wire rods	3	78,975	1,080	640	80,695	1.3	1.3	639,882	13,129	5,039	658,050	1.4	1.2
Total Semi-Finished	---	298,944	55,414	3,345	357,703	5.7	4.1	2,255,916	418,328	31,236	2,705,480	5.6	4.2
Bars—Hot rolled (incl. light shapes)	14	473,213	150,536	2,812	626,561	10.0	9.9	3,690,897	1,221,023	24,774	4,936,694	10.2	9.6
Bars—Reinforcing	15	177,158	-	-	177,158	2.8	3.7	1,190,777	-	-	1,190,777	2.5	2.8
Bars—Cold finished	16	99,893	18,758	3,417	122,068	2.0	1.7	855,979	164,175	30,069	1,050,223	2.2	1.8
Tool steel	17	797	6,707	-	7,504	0.1	0.1	8,815	55,830	-	64,645	0.1	0.1
Total Bars and Tool Steel	---	751,061	176,001	6,229	933,291	14.9	15.4	5,746,468	1,441,028	54,843	7,242,339	15.0	14.3
Wire—Drawn	23	198,514	2,920	1,926	203,360	3.2	4.0	1,763,911	26,245	18,037	1,808,193	3.7	3.6
Wire—Nails & staples	24	48,607	-	-	48,607	0.8	1.1	409,020	-	1	409,021	0.8	0.9
Wire—Barbed & twisted	25	5,579	-	-	5,579	0.1	0.2	90,915	-	-	90,915	0.2	0.3
Wire—Woven wire fence	26	17,465	-	-	17,465	0.3	0.4	227,566	-	1	227,567	0.5	0.5
Wire—Bale ties	27	7,594	-	-	7,594	0.1	0.2	44,854	-	-	44,854	0.1	0.1
Total Wire & Wire Products	---	277,759	2,920	1,926	282,605	4.5	5.9	2,536,266	26,245	18,039	2,580,550	5.3	5.4
Strip—Hot rolled	37	142,419	2,138	436	144,993	2.3	2.1	1,193,858	16,357	2,954	1,213,169	2.5	2.2
Strip—Cold rolled	38	89,558	911	18,594	109,063	1.8	1.7	* 805,049	7,991	153,240	* 966,280	2.0	1.9
Total Sheets and Strip	---	2,243,621	84,762	33,178	2,361,561	37.8	33.8	*17,533,237	625,399	256,766	* 18,415,402	38.2	32.7
Total Shipments (1955)	---	5,802,453	399,744	48,400	6,250,597	100.0	xxx	44,775,292	3,080,137	385,327	48,240,756	100.0	xxx
Total — Prior Year (1954)	---	4,209,490	249,977	30,712	4,490,179	xxx	100.0	35,375,212	2,139,213	250,284	37,764,709	xxx	100.0

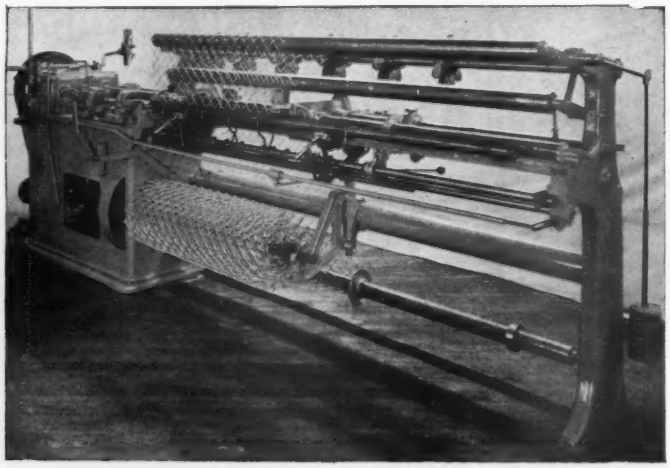
* Revised.

STEEL STATISTICS

INVINCIBLE Chain-Link Fence Machines

• Greatest in Wire Fencing!

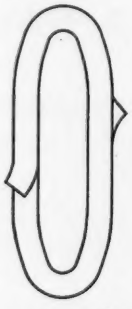
Repeat orders are good evidence and the repeats are coming



Formed with straight sides by a new action. High tension is eliminated reducing wear and power.

End view of the Spirals:

Invincible



Others

In weaving the two wires there are 4—½ turns per mesh.

INVINCIBLE'S high production cuts the wage cost. It saves power, floor space, and W I R E . With normal care the Invincible's Modern Construction gives a long life. Our capacity in building Invincibles is as yet limited. It is the machine you will "eventually buy". It gives a real chance for an increase in profits. It will pay to get in on one quickly.

A Thoroughly Modern Machine

ARTHUR BLASHILL & COMPANY

Temporary Office: 78 Downing Street

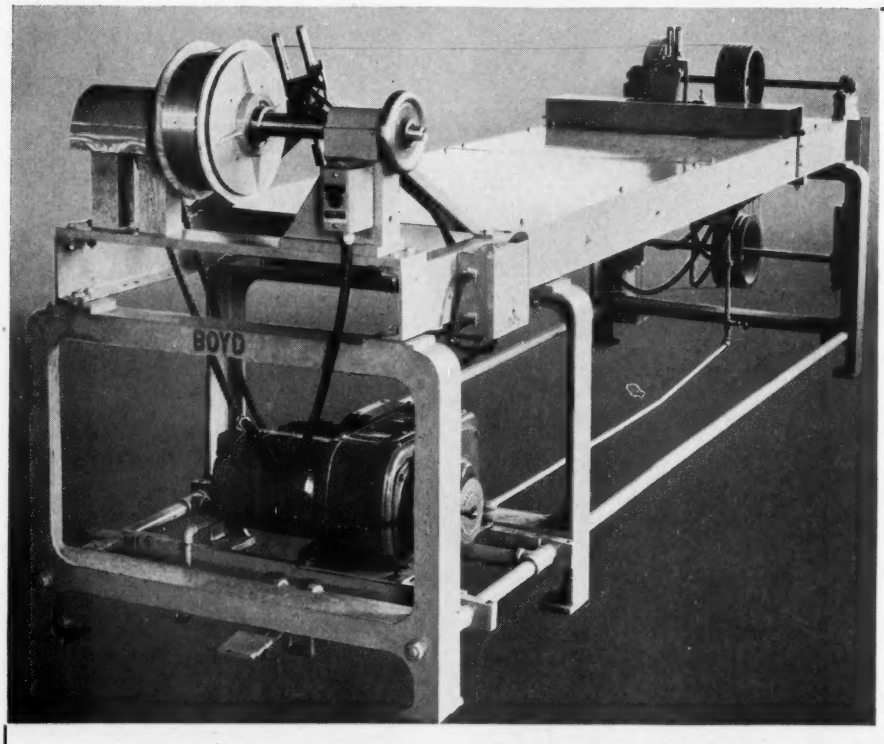
WORCESTER 10, MASSACHUSETTS, U. S. A.

ALUMINUM STATISTICS
(in pounds)
Collected by The Aluminum Association
for July 1955

	July 1955	June 1955	July 1954	1st 7 Months 1955	1st 7 Months 1954
PRIMARY PRODUCTION	265,337,163	255,265,003	252,323,794	1,785,070,173	1,683,121,430
SHIPMENTS OF ALUMINUM PRODUCTS					
SHEET and PLATE.....Total	106,996,254	125,507,746	85,551,487	790,880,478	569,310,495
Non Heat-treatable	87,830,102	99,756,704	66,243,974	627,302,612	436,394,444
Heat-treatable	19,166,152	25,751,042	19,307,513	163,577,866	132,916,051
FOIL (including foil in lamination, aluminum content only)	15,364,556	17,486,434	12,263,849	114,122,658	79,543,824
EXTRUDED PRODUCTS.....Total	34,695,652	39,914,660	24,410,205 *	232,532,366	154,205,625 *
Alloys 1100-3003-5052-6061-6062-6063	31,503,604	36,135,551	18,735,673 *	207,711,680	115,096,098 *
All other alloys	3,192,048	3,779,109	5,674,532	24,820,686	39,109,527
TUBE, Drawn.....Total	5,485,091	7,741,090	3,594,011	49,030,341	37,405,898
Alloys 1100-3003-5052-6061-6062-6063	4,846,969	7,016,538	3,068,356	45,236,336	32,249,081
All other alloys	638,122	724,552	525,655	3,794,005	5,156,817
BAR and ROD, Rolled (3/8" and over, maximum diameter across flats)	15,648,245	15,759,380	10,634,048	104,060,764	80,471,307
WIRE other than Conductor	3,944,097	4,177,178	3,008,923	26,981,179	19,948,284
ACSR and CABLE, Bare	9,229,422	12,214,033	10,212,849	70,773,262	69,409,871
Total number of companies included	98	98	96		

September 8, 1955 * Revised from previous reports. ‖ This figure includes shipments of members of The Aluminum Association and of reporting members of American Die Casting Institute, Inc.

ALUMINUM STATISTICS



"IT'S HERE"

The Boyd Micro Spooler

A low-priced, precision spooler, designed specifically for the layer winding of welding wire, offering more than has ever been available before at an unbelievably low cost. Capable of layer winding any material down to 1/32" diameter. Virtually no changes required for varying wire diameters; sheer ruggedness in construction, and the guaranteed, "built-to-last" quality and performance "Boyd" has always offered.

Savings in man hours can easily pay for the unit in a very short time. Visit and see the finest "SECOND TO NONE", reels ever produced in volume. This unit is capable of producing layer-wound reels on a top quality basis, at speeds up to 900 FPM, employing personnel in the lower income bracket to operate the machine.

Don't be convinced by mere words; assure yourself; come to see it perform, or forward wire so as to enable us to submit sample layer-wound reels for your approval.

BOYD & SONS MANUFACTURING CORPORATION

1434-38 Callowhill St. Philadelphia 30, Pa.

A Review of Recent Wire Patents

The data listed below is only a brief review of recent patents pertinent to the readers and subscribers of this publication.

Complete copies of these patents may be obtained by writing to the publisher of this magazine and remitting 50¢ for each copy desired. For orders received from outside the United States the cost will be $1.00 per copy.

No. 2,714,235, METHOD AND APPARATUS FOR CASTING STRIP METAL, patented August 2, 1955 by Joseph B. Brennan, Cleveland, Ohio.

A core, moving through a container of molten metal and thence through a die passage, is coated with a continuous tubular layer of molten metal, whereupon the coated core is cooled by a cooling medium applied to the wall of the die passage and the coating then removed to provide the strip.

★ ★ ★

No. 2,714,730, COIL SPRING FASTENING MEANS, patented August 9, 1955 by James Piliero, Chicago, Ill., assignor to The Englander Company, Inc., Chicago, Ill., a corporation of Delaware.

More specifically the means (attachment) is adapted to secure together the adjacent end convolutions of wire springs disposed one over another.

★ ★ ★

No. 2,714,790, FLEXIBLE ABRASIVE ROPE, patented August 9, 1955 by Eric R. Lindenborg, Indianapolis, Ind., assignor to Vonnegut Moulder Corporation, Indianapolis, Ind., a corporation.

An abrasive rope is disclosed comprising a flexible metallic core structure and a complete covering of granular abrasive material fastened on the surface thereof.

★ ★ ★

No. 2,715,424, WIRE FORMING MACHINE, patented August 16, 1955 by Henry H. Fante, Riverside, Mitchell J. Shepard, Cicero and August T. Gonia, Berwyn, Ill., assignors, by mesne assignments, to Rockwell Spring and Axle Company, Coraopolis, Pa., a corporation of Pennsylvania.

There are twleve claims to this machine which is adapted to bend strips of preformed zigzag wire.

★ ★ ★

No. 2,715,616, ORGANIC COATING FOR WIRE, patented August 16, 1955 by Robert M. MacIntosh, Columbus, Ohio, assignor to the United States of America as represented by the Secretary of the Army.

A self-fluxing coating for wire is disclosed consisting essentially of about 4 to 5% by weight of vinyl chloride-vinyl acetate polymer or vinyl chloridevinylidene chloride co-polymer, about 4% by weight of a mixture consisting of 1 part by weight of lactic acid and 4 parts by weight of mannitol, and the remainder, a solvent consisting of amyl acetate or a mixture consisting of 1 part by weight toluene and 1 part by weight of methyl ethyl ketone.

★ ★ ★

No. 2,715,922, METHOD AND APPARATUS FOR FORMING CABLES, patented August 23, 1955 by Herman A. Miloche, Teaneck, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York.

The method of forming local cable comprises sweeping strands of the cable a number of times over the same plane path parallel with the surface of a strand receiver in a single direction of rotation, snagging the strands at selected locations in a series of pairs of aligned locations on the strand receiver to form a series of rectangular loops all having one side in a straight line, moving each snagged strand out of the path of successive strand sweeps securing an aligned side of each loop to a juxtaposed aligned loop side, severing each loop at a point spaced from this aligned side, and removing the strands from the strand receiver.

★ ★ ★

No. 2,715,959, MULTIBLOCK WIRE-DRAWING APPARATUS AND METHOD, patented August 23, 1955 by William Elwood Zelley, Columbus, N. J., assignor, by mesne assignments, to John A. Roebling's Sons Corporation, Trenton, N. J., a corporation of Delaware.

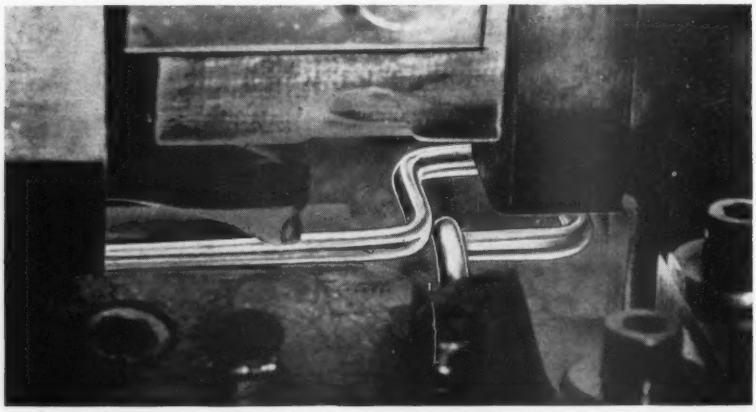
This is an electric motor-driven machine in which provision is made for varying field resistances of the motors individually to vary the speeds of the respective motors thereby selectively to operate the corresponding blocks faster than the wire to provide slippage between the blocks and the wire, to operate the blocks as substantially the speed of the wire without slippage or to operate the blocks with a selected tension on the outgoing wire.

★ ★ ★

NILSON 4-SLIDES PAY OFF 4 WAYS

• BIG PROFITS • BIG PRODUCTION

• BIG SAVINGS • BIG GAIN IN ACCURACY



Forming Operation: Meter Shunts of 3/16" Wire Stock

WHY NILSON IS TOPS FOR 4-SLIDES:

Nilson 4-Slides are built for rugged duty

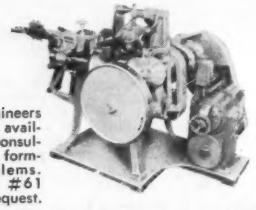
Form both ribbon metal and wire stock

Press capacities 8 to 75 tons, wire diameter to ½"

16 Models Available, Including Combinations of Horizontal Press and 4-Slide

YOU PROFIT BY:

Automatic Operation • Increased Production • No Secondary Handling • Improved Products • Fewer Rejects • Lowest Initial Cost



Nilson engineers are always available for consultation on forming problems. Bulletin #61 sent on request.

Nilson's 3 tilt and 3 stationary reels handle wire or ribbon stock coils up to 500 pounds.

A.H. NILSON MACHINE COMPANY

1516 RAILROAD AVENUE, BRIDGEPORT 5, CONN.

Automatic Chain Making Machines • Staple Forming Machines • Wire and Stock Reels • Wire Straightening Equipment • Slide Feeds for Presses • Wire and Ribbon Stock Forming Machines

No. 2,716,007, APPARATUS FOR COILING WIRE, patented August 23, 1955 by Roger M. Scott, Worcester, Mass., assignor to Morgan Construction Company, Worcester, Mass., a corporation of Massachusetts.

The apparatus comprises a main body, a spider rotatably mounted on the main body, a block rotatably mounted on the spider, a restraining member adjacent the block, and a magnetic device associated with the block and the restraining member to restrain their rotation relative to each other.

★ ★ ★

No. 2,716,308, APPARATUS FOR MAKING SPRING UNITS, patented August 30, 1955 by Frederick G. Hodges, Jr., Janesville, Wis.

Apparatus for making spring units for cushions or the like is disclosed and comprises a device for feeding coil springs into predetermined juxtaposition relative to each other to form a predetermined spring pattern with the axes of the springs in parallel relation and a device for progressively securing the springs together both longitudinally and transversely to form a spring unit structure.

J & L Acquires Land for Mill in Connecticut

Jones & Laughlin Steel Corporation, the nation's fourth largest producer, has purchased a thirty-one acre site at Willimantic, Conn. **C. L. Austin,** president, said the land will be used initially for construction of a plant to produce cold finished steel bars. The site was bought from the **American Screw Company** of Willimantic.

★ ★ ★

Jones & Laughlin now has cold finishing facilities at Pittsburgh and Hammond, Ind. Mr. Austin said Willimantic was chosen for the new plant because of its central location in relation to the expanding New England market.

★ ★ ★

Cold finished steel bars are used by the machine tool and screw machine industries, where the bars are fashioned into the moving parts of machines such as those used by textile and shoe manufacturers.

★ ★ ★

The company has spent nearly $500,000,000 on plant expansion and modernization since World War II. Cost of the cold finishing plant at Willimantic, to be put into operation next year, is in addition to $135,000,000 already earmarked for expansion and improvement purposes in 1955-56.

Firth Sterling Further Integrates Carbide Production

Firth Sterling Inc. has announced the acquisition of a half interest in a newly formed company, **Strategic Metals Corporation,** with facilities located at Conshohocken, Pa. This plant is engaged in the chemical beneficiation of complex tungsten ores and residues into suitable feed material for Firth Sterling's ammonium paratungstate plant in Trafford, Pennsylvania.

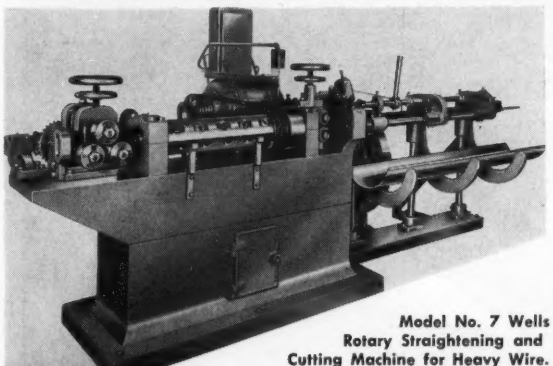
★ ★ ★

With a capacity for upgrading 150 tons per month of complex tungsten-bearing materials, the new facility further integrates Firth Sterling's production of tungsten carbide products by providing a constant and dependable source of high purity raw material in the form of calcium tungstate. Since the total capacity of the Conshohocken unit is in excess of Firth Sterling's requirements, the plant will operate on a toll basis, beneficiating tungsten bearing materials for others.

A Fast, Dependable Wells

STRAIGHTENER AND CUTTER FOR HEAVY WIRE

Shown below is the famous Model No. 7 WELLS ROTARY STRAIGHTENING AND CUTTING MACHINE designed for a maximum of durability and service.



Model No. 7 Wells Rotary Straightening and Cutting Machine for Heavy Wire.

Flyer runs in ball bearings. All wear parts made of tough steel for long, trouble-free operation.

Motor and gears are readily accessible through door in base.

A highly satisfactory machine for day-in, day-out production.

This machine is designed to handle 1/4", 5/16", 3/8", 7/16" and 1/2" wire at speeds of 90' to 100' on long continuous production runs. Other WELLS MACHINES are made to handle smaller gauges of wire at correspondingly higher speeds.

Backed by 59 years of experience and development

Send for Catalog covering the full line.

Frank L. Wells Company

KENOSHA • 5821 Fifth Avenue • WISCONSIN

Builders of Fine Wire Working Machinery

Comments on Pressurized Dies

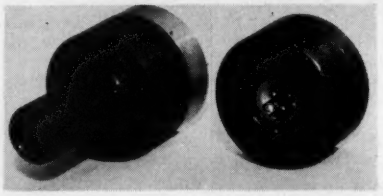
As a result of an article on this subject that appeared in the May, 1955 issue of Wire and Wire Products, starting on page 560, J. G. Wistreich, Head of the Metal Working Laboratories of the British Iron and Steel Research Association, Sheffield, England, has vouchsafed some comments on the subject that we are happy to publish. A technical treatise on the subject appeared in the March issue of The Chartered Mecnanical Engineer, so that the idea is not only not new, but has been tried out in England. Mr. Wistreich's letter is quoted below:

★ ★ ★

"Your readers and Mr. Maurice P. Milliken, author of the article 'Pressurised Dies for Wire Drawing', published in the May issue of your Journal, will be interested to learn that a practical system of 'forced lubrication' has been developed by us and is meeting with outstanding success in current trials by British steel wire mills.

★ ★ ★

"Fig. 1. shows side by side, a conventional die and one form of the unit developed by us, for use with metallic soap powder as lubricant. Following the installation of these units in the roughing holes of modern high-speed machines, lubrication visibly improves in *all* holes, dies last five to ten times as long as normally, and lubricant films up to



0.002" thick have been measured. Our industrial experience is, at the time of writing, confined to mild steel and medium carbon steel drawn from rod, but in our laboratories we have successfully experimented with high carbon steel, stainless steel, and other materials.

★ ★ ★

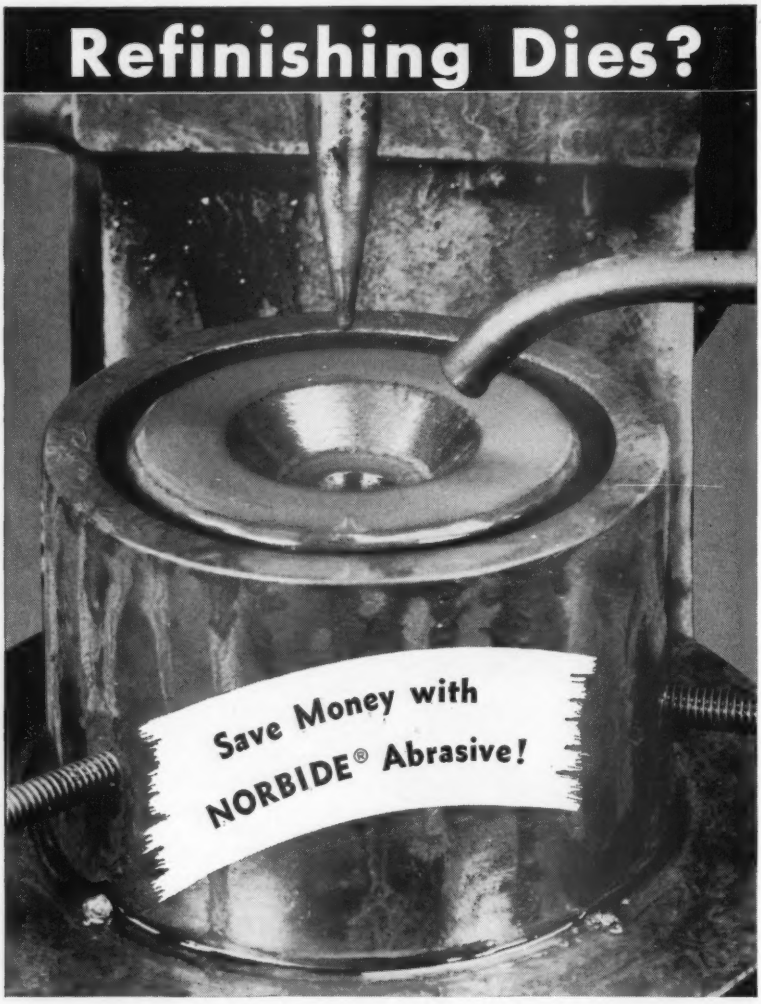
"The aforementioned developments have their origin in the researches of Professor Christopherson of Leeds University, who has invented the method and established the theory of hydrodynamic lubrication of wire by mineral oil. His system, from which ours differs in the nature of the lubricant and the design of the unit, opens further possibilities in the field of drawing at very high speeds, since in addition to the greatly improved die life already noted, the use of fluid lubricants opens the way to more efficient cooling. Professor Christopherson's theory is the subject of a paper presented this spring to the Institution of Mechanical Engineers in London. His laboratory experiments were described in the Symposium on Metal Working Lubricants organised by the Institute of Petroleum in London in March, 1954.

★ ★ ★

"Both systems are covered by patent applications held by the National Research and Development Corporation of Great Britain.

★ ★ ★

"I trust that, in view of the foregoing attainments which are based on several years of research, Mr. Milliken will allow me to criticise some of the ideas contained in his article. The pressure between wire and die amounts to 20,000-200,000 psi, depending on the nature of the wire, reduction, and die profile. The lubricant must be maintained at about this pressure if it is to perform the desired function. To design and operate a circulating system at this pressure is no mean task even for research purposes and could hardly be tolerated in a wire mill. The pressure gland ahead of the die, envisaged by Mr. Milliken will either fail to function at these pressures or, if maintained by means of a preliminary reduction of the wire, will defeat the purpose of the scheme (since it virtually becomes another die which must be lubricated). Fortunately, these difficulties need not be faced because the wire can be made to act as its own pump and gland, with the die performing the function of a throttle; this is the principle



You may never use a wire drawing die this large, but no matter what size dies you're refinishing, you can save money by using NORBIDE Abrasive — rather than costly diamond dust — for ripping or fast stock removal as well as for accurate semi-finishing operations. For details, write for Form 559.

NORTON
BORON CARBIDE

NORTON COMPANY
New Bond Street
Worcester 6, Mass.

underlying the Christopherson and BISRA systems.

★ ★ ★

"Mr. Milliken is quite right in believing that pressures can be attained which will cause the wire to be extruded rather than drawn through the die. Unfortunately, this does not lower the pull, because of the back tension which must be balanced by an appropriate forward pull if the wire is not to go into reverse! Professor Christopherson has made numerous measurements of pulls and pressures, with soft copper and mild steel wires, steel dies and mineral oil, from which it is evident that the pull is changed little if at all by pressures up to 40,000 psi. His results are borne out by our experience with soaps, waxes and other solid lubricants.

★ ★ ★

"In conclusion, may I express the hope that Mr. Milliken, though his idea has been anticipated by others, will find satisfaction in the thought that their findings fully bear out the benefits expected by him in his 'educated guesses'."

New Anaconda Mill In Sycamore In Operation

Anaconda Wire & Cable Company has started production of aluminum wire and cable in a new completely modern building at Sycamore, Ill.

★ ★ ★

When operating at capacity, the new self contained factory will quadruple output of bare, rubber-insulated and synthetic-insulated aluminum wire and cable at Sycamore. As in all other Anaconda Wire & Cable Company mill locations, aluminum and copper production is carried on in separate locations to eliminate possible contamination of one metal by the other.

★ ★ ★

The new aluminum mill is fully equipped with automatic machinery for drawing, stranding and insulating aluminum wire, and is the eighth in a series of expansion steps taken at Sycamore since 1940. In that time the capacity of the mill has more than tripled.

★ ★ ★

The Sycamore mill, established in 1895 by the former Chicago Insulated Wire Company, was acquired by Anaconda in 1929 to produce copper wire and cable and magnet wire for the middle western market.

★ ★ ★

The addition of aluminum capacity here is the most recent example of Anaconda's increasing interest in the white metal. Other aluminum facilities are the Anaconda Aluminum Company's reduction mill at Columbia Falls, Mont., and the Wire and Cable Company's rod-rolling mill at Great Falls, Mont. These facilities complement aluminum manufacture at Hastings-on-Hudson, N. Y., Marion, Ind., and Orange, Calif.

★ ★ ★

Charles B. Townsend is the Sycamore mill manager.

Rem-Cru Expanding

Rem-Cru Titanium, Inc. has announced the purchase of a group of five buildings and ten acres of land from the **Crucible Steel Company of America** in Midland, Pa., as another step forward in the company's expansion program for tonnage production of titanium mill products.

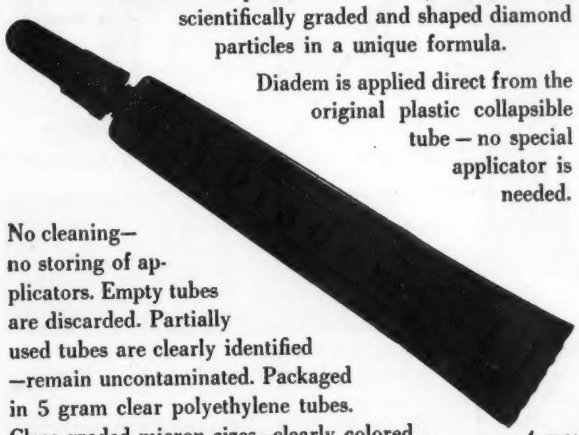
★ ★ ★

C. I. Bradford, President and General Manager of Rem-Cru, in making the announcement stated: "The purchase of this property will

Diadem | DIAMOND POWDER COMPOUND

Diadem Compounds are made by incorporating scientifically graded and shaped diamond particles in a unique formula.

Diadem is applied direct from the original plastic collapsible tube — no special applicator is needed.



Approximate size

No cleaning— no storing of applicators. Empty tubes are discarded. Partially used tubes are clearly identified —remain uncontaminated. Packaged in 5 gram clear polyethylene tubes. Close-graded micron sizes—clearly colored for easy recognition. Further information about DIADEM upon request.

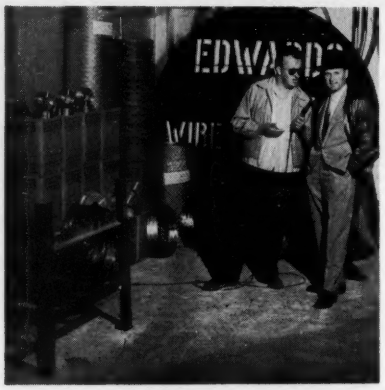
WHITTAKER CLARK & DANIELS, INC.

allow us to move toward our goal of constructing completely integrated facilities for producing titanium mill products. It is a firm expression of our confidence, not only in titanium's increasingly vital role in providing a practical material of construction for supersonic aircraft and light weight ordnance equipment, but in titanium's place in the future of American industry in the chemical, petroleum, marine, electronic and transportation fields. New equipment specifically engineered for processing titanium will be installed in the purchased buildings as rapidly as required to meet increasing demand. These special facilities will permit us to produce better quality products at lower cost and thereby open up new markets for titanium."

★ ★ ★

E. H. Edwards Co. Featured on TV

The story of how Edwards "Sterling Steel" wire rope is produced was told in word and picture recently on San Francisco's award-winning "Success Story" television show. The telecast traced the manufacture of wire rope step-by-step through wire drawing, heat treating, cleaning, patenting, recleaning, drawing, galvanizing, and



testing. Shown here during final rehearsal are **Sterling Edwards,** (right), president of the company, and "Success Story" master of ceremonies **Bob Day.** Edwards' garment hangers, stitching wire, stucco netting, and fish trap netting shown here in the background were also featured on the half-hour show.

★ ★ ★

The E. H. Edwards Co. plant is headquartered in South San Francisco, California.

Originally a Nail Factory; Now Making Wire Cutters

The M. W. Robinson Company, Rockfall, Conn., manufacturers of mechanics' tools and hardware specialties, has roots deeply embedded in our history.

★ ★ ★

A factory was erected in 1789 by **Jehoshaphat Stow** to make cut nails by machine that is thought to be, according to the "History of Middlefield and Long Hill" by **Thomas Atkins,** the first of its kind in America and probably in the world. The cutting machine was invented by **Daniel French** of Berlin, Conn.

★ ★ ★

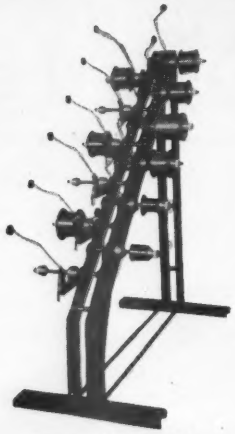
Iron wire was made at the plant from 1812 to 1816, during the war with Great Britain, but was discontinued when peace came and cheaper wire began to be imported.

★ ★ ★

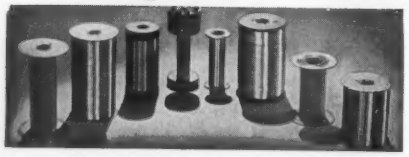
STANDARD UNI-DRIVE WIRE WINDER

INCREASE YOUR PRODUCTION WITH THIS WINDER

Wire Winder



Pay-off Attachment



Various types of supply packages that may be wound on Standard Uni-Drive Wire Winder.

PAYOFF

Our payoff attachment is made with self-aligning ball bearings and a compensating attachment to control the tension of each end. Applies same tension when spool is empty as when full.

The new Uni-Drive Winder with Payoff Attachment is new in design and incorporates several improved and tested features. Production is stepped up through increased speed. It produces smooth, even and accurately wound spools of wire in single or multiple ends. All strands parallel—no over or under-winding. Automatic Stop-Motion controls each strand. Compensating attachment produces perfectly controlled tension. Traverse adjustable from 1¾" to 5½" between spool heads without changing cam. Designed especially for winding wire to be braided and shielded for electrical conductors up to ¾" diameter.
Payoff can be equipped with Carboloy Guide Inserts at additional cost.

STANDARD MILL SUPPLY COMPANY
PAWTUCKET, RHODE ISLAND, U.S.A.
1064-1080 Main St.
PAwtucket 3-1534 — 3-1535 — 3-1536

In 1845 the mill was purchased from the heirs by **Henry Aston** and others and production was started on the making of pistols for the Government on a large scale. One of the partners, **Ira N. Johnson,** bought the business in 1852 and continued the manufacture of pistols until the shop was burned down in 1879.

★ ★ ★

Otis A. Smith, another manufacturer, bought the fire-gutted mill in 1881 and rebuilt a 100x30 three-story building. Here he made the "Smith Revolver" and a line of hardware. His heirs sold to **R. D. McKinney** and **T. Nesbit** in 1923, whose families still own the business, now operating under the name M. W. Robinson Company, making tools for wire and other hardware products.

Announces Line of Carbide Spring Tooling

Arthur A. Crafts Co., Inc., 603 Newbury Street, Boston, Mass., announces a complete line of precision quality carbide spring coiling machine tools for Torrington and Sleeper and Hartley machines. Although Crafts has been doing a moderate volume in these tools for several years, they have recently set up a complete optical grinding department devoted entirely to these items and are shipping the majority of orders from stock.

★ ★ ★

Established in 1900 as a manufacturer of industrial diamond tools, the advent of tungsten carbide in 1928 found Crafts well equipped to fabricate tools of the new material. Since that time, the organization has grown steadily and through its engineering departments has designed and built special machinery, particularly optical grinding equipment, which allows the firm to guarantee accuracy of grooves and contours never before attained.

★ ★ ★

With plants in Boston, Chicago and Detroit and factory-trained representatives in Philadelphia and Bristol, Conn., the Arthur A. Crafts Company offers the spring-making trade the highest quality carbide tooling with complete engineering service when required. A price list is available upon request.

Aluminum Taschenbuch

Published 1955, 11th ed., by Johannes Reiprich and W. V. Zuehl, Aluminum Verlag, GMBH, Dusseldorf, Germany. 965 pages, with many illustrations and tables. Price: 17 DM (Approx. $4.00). About 50% larger than the last edition, published in 1951.

★ ★ ★

The book starts by listing the consultation and information services of the German Aluminum Association, their recommendation and training courses for technicians in the aluminum industry. A complete history of aluminum is followed by an outline of the commercial development of this light metal.

★ ★ ★

Chapter 2 covers aluminum from raw materials to the metal. Discussion of the Bayer process, electrolysis, production of very pure AL (Raffinal), working of scrap, SAP, continuous casting

INSULATING and FINISHING COMPOUNDS for WIRES and CABLES

CARBRO has specialized in Compounds for Saturating and Finishing Insulated Wires and Cables since 1939.

- **CARBRO WIRE PAINTS**

  Fast drying, high hiding, finely dispersed pigmented compounds for use over stearin and asphaltic finishing pitches. We also manufacture Service Entrance Gray Wire Paints.

- **WIRE PAINTS for use on NEOPRENE INSULATION**

  These specially prepared paints are finely dispersed, fast drying and flexible, and have excellent adhesion. Produced in practically any desired color. The non-volatile content is flameproof.

- **FLAME RESISTANT PIGMENTED LACQUERS**

  Primarily for use on switchboard wires—flexible, fast drying, with higher viscosities than conventional wire paints.

- **THERMOPLASTIC FINISHES**

  Clean Hot-Melt Compounds for switchboard cables and building wires.

- **ALUMINUM VARNISH for NAVY and SHIPBOARD CABLES**

- **FLAMEPROOF SATURATING MATERIAL (cold type) for all FIBROUS COVERINGS.**

✦

CARBRO CHEMICAL COMPANY

Dunnell Lane • Pawtucket, R. I.

and fabricating, such as rolling, extrusion, wire drawing, etc.

★ ★ ★

The next chapter gives a brief review of AL as a metal, its alloys, German specifications, shapes in which it can be obtained and German trade names. A list compares U. S., Canadian, British, French, Swiss, Italian, Austrian and German designations.

★ ★ ★

Chapter 4 presents the properties of AL alloys, chemical composition and physical properties, and Chapter 5 is on chemical properties and chemical behavior. A table of 34 pages gives the chemical behavior of pure AL, commercial AL and 99.5% AL which has been given either surface protection or which has been treated with inhibitors. Another table gives the AL content found in food products.

★ ★ ★

Chapter 6 is on materials testing. Briefly chemical analytical methods and spectrochemical are described. Also, macro and microscopy and non-destructive testing. Chapter 7 covers recommendations for plant handling, storage and installation of the metal.

★ ★ ★

Chapter 8 reviews the properties, uses and the working of wrought alloys and of SAP. This chapter allows the reader to evaluate the various alloys and the possibilities of fitting them to his needs. A similar approach is followed in Chapter 9, which is devoted, however, to casting alloys.

★ ★ ★

The deformation and heat treatment of wrought alloys is the subject of Chapter 10. Chapter 11 is on alloy behavior in the machine shop, tools to be used to saw, drill, etc., this series of alloys. Chapter 12 is on joining. Joints made by means of soluble or insoluble agents, as well as mechanical joints due to atomic forces are covered.

★ ★ ★

Chapter 13 describes in some detail the uses of the surface treatments recommended. Recent articles published in 1955 in the German magazine "Aluminum" are covered in this section. Mechanical and chemical surface treatments, chemical oxydation, phosphatization, anodic oxydation (technical, decorative, and for photographic purposes). Brightening, chemical coloring, metal coatings, cleaning and care of AL and non-metallic coatings.

★ ★ ★

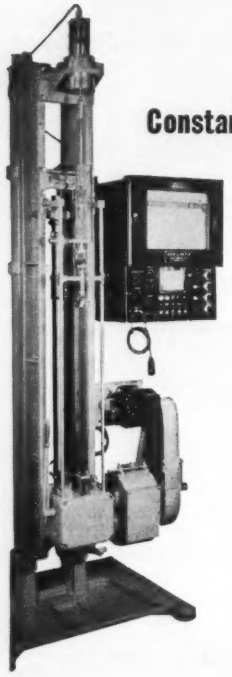
Chapter 14 deals with non-metallic layers applied to AL. Chapters 15 and 16 are concerned with instructions for the use of aluminum and its alloys. Chapter 17 is on AL foil and strip. Chapter 18 is on aluminum powders and their uses.

★ ★ ★

Chapter 19 is on the use of AL for improving other materials, particularly steel. (Aluminizing methods, etc.) Chapter 20 describes in detail the uses of AL in the electrical industry where it is used as cable and wire. Chapter 21 is an appendix in which the German specifications that have to do with AL and its alloys are

NOW FOR THE FIRST TIME

A PRECISION tester capable of recording all of your tensile results in POUNDS PER SQUARE INCH or equivalent units.



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— copper, tungsten, silver, etc. varying in diameter.

Metal
— sheet or strip varying in thickness or width.

Rubber
— standard dumbell specimens varying in thickness.
— tubing or insulated wire jackets varying in O.D. & I.D.
— thread varying in square mils.

Textile
— yarns varying in tensile.

Any specimen of any material with measurable area.

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PSI = LOAD/AREA

any or all of the above are readily attainable.

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reproduced. A series of practical tables to be used in the shop are also in this chapter. Chapter 22 lists books on aluminum and contains the names of technical magazines which deal with AL and its alloys.

★ ★ ★

The book is complete with a subject index. It is well cross-referenced, well printed, easy to read and of pocket size. It would seem to be very valuable to both the aluminum user and prospective user, willing and able to read German, and to the aluminum industry in general.

Signal Corps to Hold Fourth Symposium

The fourth annual symposium on "Technical Progress in Communication Wires and Cables" sponsored jointly by the Signal Corps Engineering Laboratories and the Wire and Cable industry, will be held December 6, 7 and 8 at the Berkeley-Carteret Hotel in Asbury Park, N. J.

★ ★ ★

The three-day gathering of leaders in the fields will cover the subjects of wire and cable construction, their characteristics and uses, conducting, insulating and jacketing materials, manufacturing equipment, processes and techniques; field construction practices and the end uses in operating systems.

★ ★ ★

Companies and agencies which had representatives in attendance at previous symposiums will be contacted. Others desiring to attend were advised to obtain further details from **H. L. Kitts, Chairman,** or **H. F. X. Kingsley** of the Symposium Committee at Eatontown 3-1000, Extension 51565 or 51564.

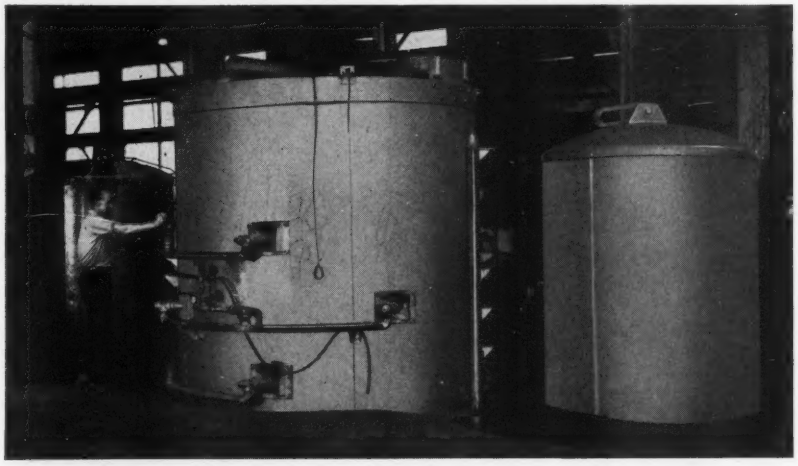
New Comprehensive Guide Available on Selection of Specialty Steels

A new 32-page, illustrated guide to specialty steels is now available to all steel users. Issued by **The Carpenter Steel Company,** Reading, Pa., the booklet defines the distinctive characteristics of a broad range of special purpose steels in terms of end use. It briefly summarizes the company's specialty product line, covering tool and die steels; stainless steels; silicon and high nickel electrical alloys; special purpose alloy steels; valve, heat-resisting and super alloy steels, tubing and pipe in various analyses and fine wire specialties. Corollary information is also given on the quality control necessary in the manufacture of specialty steels. The guide is intended to help match the proper steel to the job, and thus improve tooling, fabrication and product performance. For a copy, write

The Carpenter Steel Co.,
3050 W. Bern St.,
Reading, Penna.

To Build Nuclear Reactor

Continental Can Company has joined seven other companies in the construction and operation of a nuclear reactor which Continental will devote to research on the development of new, improved products and materials in the packaging field.



Bright Annealing Wire Uniformly in ROCKWELL BELL FURNACES

In this Rockwell installation four furnace bases and one gas fired, bell type furnace provide the required operating flexibility of heating, loading and unloading the work. Each base is equipped with a circulating fan to distribute heat uniformly to the charge.

A steel hood is placed over the work and sealed tight. The load of copper product is bright annealed in a protective atmosphere and cooled in the hood.

ROCKWELL ALSO BUILDS
Batch and continuous furnaces and ovens for annealing, aging, drying, enameling, tinning, glass coating, synthetic coating. Atmosphere generators.

Rockwell bell furnaces (cylindrical or rectangular) are built to specifications for bright annealing steel and non-ferrous wire in coils or on spools.

Write for Bulletin 432 on Rockwell Wire Mill Furnaces.

ROCKWELL SINCE 1888 BUILT

W. S. ROCKWELL COMPANY
FURNACES • OVENS • BURNERS • VALVES • SPECIAL MACHINERY
2425 ELIOT STREET • FAIRFIELD, CONN.
Sales Representatives in Principal Cities

Production and use of certain isotopes and experimentation in the irradiation of packaging materials will be available to Continental when the reactor is completed in late 1956 or early 1957.

★ ★ ★

The Industrial Reactor Laboratories, as the facility will be called, will be located on a 250-acre tract either in New Jersey or New York. It will cost between one and one-half million and two million dollars.

★ ★ ★

Operation of the laboratories will be directed by a leading university, according to a policy set down by the board of directors which is composed of representatives of the various companies.

New Book on Industrial Waste Treatment

"Principles of Industrial Waste Treatment" by **C. Fred Gurnham** was published in August by **John Wiley & Sons**, 440 Fourth Ave., New York 16, N.Y. Approaching the subject from an operational or unit operations point of view, the new book deals with the sources, pollutional effects, and methods for the treatment and disposal of liquid wastes produced by industry.

★ ★ ★

Dr. Gurnham first deals with the effects of wastes on streams and sewerage system. Following this, he examines the criteria developed by the sanitary engineer for evaluating pollution; physical, chemical, organic, and biological properties are considered separately.

★ ★ ★

The greater part of the book covers the operations and processes used to treat industrial wastes before their discharge into natural waters or municipal sewers. In the three chapters devoted to physical treatment, Dr. Gurnham analyzes sedimentation, filtration, and heat transfer operations. The four chapters on chemical treatment consider pH adjustment, oxidation and reduction, coagulation and chemical reaction, and adsorption and ion exchange. In the discussion of biological treatment, Gurnham includes biological filtration, activated sludge and lagoons. Anaerobic biological treatment and miscellaneous methods are also covered. Disposal programs and brief descriptions of industries with major disposal problems conclude the volume.

★ ★ ★

The author is professor and head of the department of chemical engineering and professor of civil and sanitary engineering at Michigan State College.

★ ★ ★

"Principles of Industrial Waste Treatment" contains 399 pages and is priced at $9.50.

Welded Wire Mesh Concern Moves Plant from Puerto Rico to U. S.

National Wire Products Corp., formerly U.S. Metals Corp., has moved its plant from San Juan, Puerto Rico, to Fischers Road and Penna. R. R., Baltimore 22, Md. The company manufactures concrete reinforcement mesh and other wire products. Operations have already begun at the Baltimore address.

★ ★ ★

At a recent directors' meeting, **H. C. Youngen** was elected president and **Ray C. Faust** was elected secretary and treasurer.

USERS OF THESE CABLE REEL BORERS REPORT

PRODUCTION INCREASES UP TO 500%

In one single operation, this remarkable machine bores ALL the holes in a wooden cable reel head. In addition, it has the exclusive Root Patented Hydraulic Feed which provides a stepless range of feed from 2 to 29 strokes per minute. Operator is not handicapped by limited feed rate. This increases production tremendously. Can also be used for other boring purposes. Made in three sizes. *Write for Bulletin No. 132.*

"Can honestly say this machine alone has increased our production over 200%! Our profits increased 100%!"
V. Fairhurst, Mgr.
New England Reel and Lumber Co.

ROOT
HYDRAULIC FEED
REEL BORER

Root Reel Borer being used by New England Reel & Lumber Co.

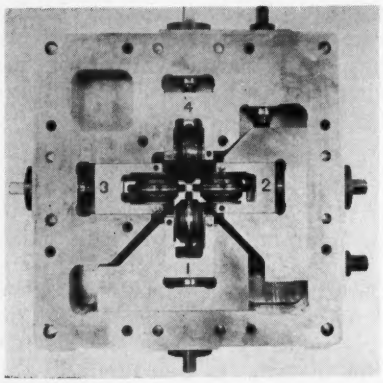
B. M. ROOT CO YORK, PA.

"Turks Head Redesigned"

A new design of Turks Head manufactured by The Fenn Manufacturing Company, Newington, Conn., combines features formerly requiring two distinct models. This new development permits the forming of most special shapes with a simple roll change, and the forming of all conventional squares and rectangles within the head's capacity by simple roll adjustment.

★ ★ ★

In this new design, known as model TH, this is accomplished by separate adjusting screws which control horizontal and vertical adjustments of slides No. 1 and 2. Slide No. 3 is capable of horizontal adjustment only, while slide No 4



Fenn's Type TH Turks Head, with frame cover removed.

is adjusted vertically. The new independent adjustments of slides 1 and 2, plus the horizontal travel of slide No. 3, permits setting the type TH Turks Head for either the universal or special operation.

★ ★ ★

In addition to the important feature above, bearing capacities have been substantially increased so that higher production speeds can be obtained, the frame is a steel fabrication to increase strength in a small area, and overall time required for roll setting has been materially reduced.

★ ★ ★

New Type Plating Barrel for Automatic Handling of Large Batches

(*Continued from page* 1178)

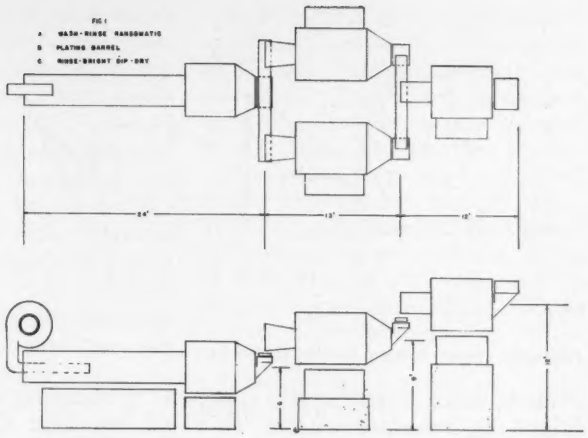
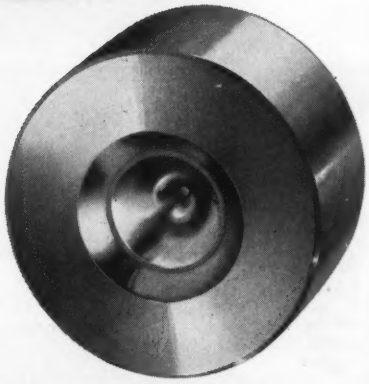


Figure 1.

WILLEY'S
TUNGSTEN CARBIDE

METALS
DIES
TOOLS
for the Wire Industry

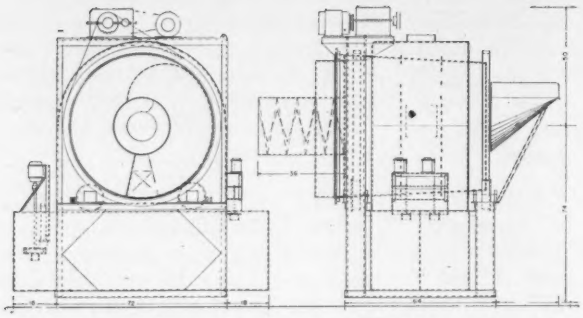


Rough Cored Standard Dies
(from stock)
ROUND SQUARE HEXAGON OCTAGON

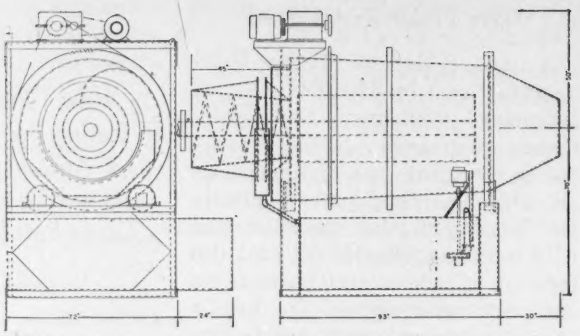
Rough Cored or Finish Ground
(Immediate quotations on receipt of your prints—
Fast delivery schedules)
SPECIAL DIES WEAR PARTS MANDRILS
NIBS—HEADING AND EXTRUSION DIES

For complete information:

Willey's Carbide Tool Co.
1340 W. VERNOR HWY. • DETROIT 1, MICHIGAN



Projected elevation drawing showing plating barrel. * * * * * * *



Projected elevation drawing showing Ransomatic. * * * * * * *

chine in which it may receive rinse, bright dip, hot rinse and dry. This is a standard continuous machine of the type that we have been building for a great many years. It is made with a holding drum at the charging end so that a complete batch may be charged into it and fed through the necessary processes at a uniform rate. The advantage of this setup, as above stated, is that large batches may be handled as a unit with a minimum amount of labor. In addition to the labor saving features of the equipment, we have found that circulation of the electrolyte, as well as keeping the anodes in motion during the plating cycle, is advantageous.

★ ★ ★

While this unit is adapted to handling any plating job in which the user has large batches of comparatively small parts, we believe it has a special application in the nail industry. Where the general run of nails is wet tumbled, the Ransomatic is not necessary, since the nails may be taken from the cleaner to the plating barrels.

★ ★ ★

The hot galvanizing of nails has always been an operation which requires a good deal of unpleasant labor not only in the actual loading and unloading of the work but also granulating the zinc and other similar operations that are a part of the process. In the equipment described the work is loaded at the charging end and is never handled until it comes out of the final drier to be put into kegs or cartons. This, of course, greatly reduces the labor cost of the zinc coating operation. In addition to this the maintenance on this equipment will be very much lower than the maintenance on a rotating galvanizing furnace.

THE NEW LOOK

IN DIAMOND DIES

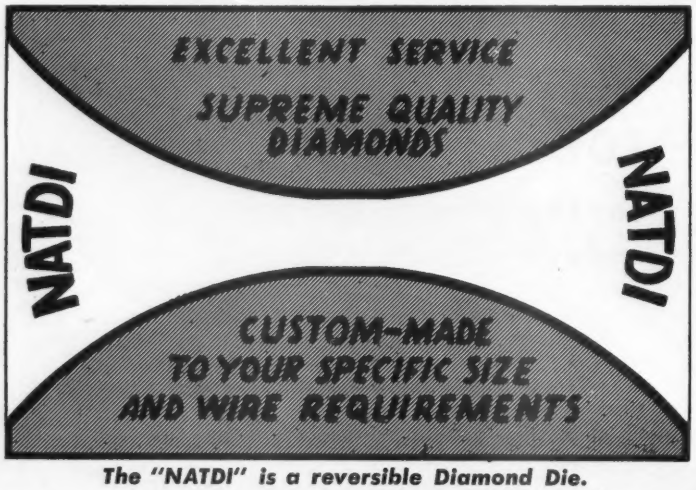
This is what you have been waiting for!
It is the answer to lower production costs.

GET THE UTMOST LIFE AND SERVICE
FROM YOUR DIAMOND DRAWING DIES.

NATIONAL WIRE DIE CO.

PRESENTS

THE "NATDI"



The "NATDI" is a reversible Diamond Die.

We waited months for full proof, so that you could be sure of the new die's performance. Customer's report:

1. UP TO 100% MORE PRODUCTION AT THE INITIAL SIZE.
2. AMAZING ABILITY TO BE RE-CUT WITHOUT SKIPPING SIZES. THIS MEANS MORE RE-CUTS PER DIE.

Our representatives will gladly call on you at your convenience.

NATIONAL WIRE DIE COMPANY
30 Irving Place, New York 3, N. Y.
Tel.: GRamercy 3-7622 and 7123

COPPERWELD STEEL INTERNATIONAL
Exclusive Export Representatives
117 Liberty St., New York 6, N. Y.

Mineral-Insulated Metallic-Sheathed Cables

(*Continued from page* 1243)

The Gland

The gland consists only of three parts:

1. **The gland body.**
2. **The compression ring.**
3. **The gland nut.**

★ ★ ★

Before attaching the cable seal termination the gland is slipped over the end of the cable in this order, first the gland nut, then the compression ring and last the gland body. When the cable seal termination is completed the gland body is slipped against the cable seal; the outer end of the gland body is counterbored so that it slips over the cable seal. The compression ring is then moved up to the gland body and the gland nut tightened on the gland body. This forces the compression ring between the cable sheath and the gland body and locks the latter in place on the cable sheath. The outer end of the gland body has a male thread for direct attachment to threaded fittings and boxes or enclosures of the threaded boss type, or to accommodate standard locknuts for coupling the gland to any standard box. Figure 5 shows a complete terminating fitting installed on a two-conductor Type MI cable, consisting of a cable seal termination and a gland assembly.

Special Fittings

Work is progressing on the development of a more complete series of terminations suitable for use over the temperature range of 85 C to 250 C and for hazardous locations.

★ ★ ★

National Electrical Code - 1953

Following a very extensive evaluation by the Underwriters' Laboratories, mineral-insulated cable was incorporated in the 1953 National Electrical Code. It is called Type MI wiring and this is the first time that this type of insulation and wiring has been recognized in the National Electrical Code.

★ ★ ★

Type MI wiring may be used for services, feeders, and branch circuits and is suitable for use in dry or wet locations and for continuous exposure to weather. It is approved for exposure to oil and gasoline, may be embedded in masonry or concrete and may be buried directly in the earth. Where the sheath is exposed to highly corrosive conditions, such as in certain types of cinder fill or in certain chemical plants, protective coverings are required.

★ ★ ★

Type MI wiring has a maximum operating temperature rating of 85 C (185 F) when used with the standard (Type 0) termination. This standard termination, rated at 85 C (185 F), provides a moisture seal and is required at all points where the cable terminates. Type MI cable itself has a maximum operating temperature of 250 C (482 F) and may be used up to this temperature if special terminations are employed or if the wiring is arranged so that the terminations are located in cooler environments.

REDUCE BREAKAGE
LOWER COSTS
WRAP BETTER
with
"Arksafe"
CRINKLED KRAFT
WIRE WRAP!

Quick delivery of plain or waxed single ply crinkled kraft; asphalt or non-staining resin laminated; polyethylene coated or polyethylene laminated. Reinforced for extra strength when needed.

In sizes to fit your present equipment.

For details write Dept. WP-3.

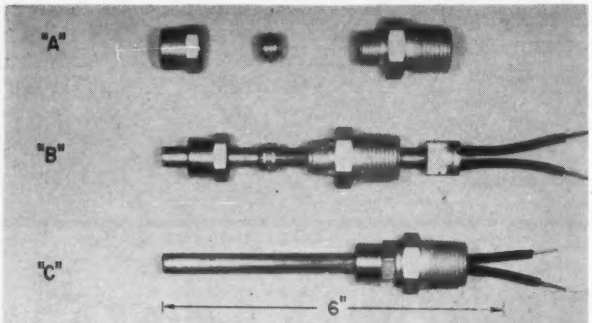
ARKELL SAFETY BAG COMPANY
70 EAST 40th STREET (Established 1896) 6345 WEST 65th STREET
NEW YORK 16, N. Y. CHICAGO 38, ILLINOIS
Plants: Chicago, Illinois, and Newport News, Virginia

High Frequency Cables, JAN-C-17A

The relatively low dielectric constant (SIC) and the extremely low dielectric loss of magnesium oxide make this insulation suitable for use at high frequencies.

★ ★ ★

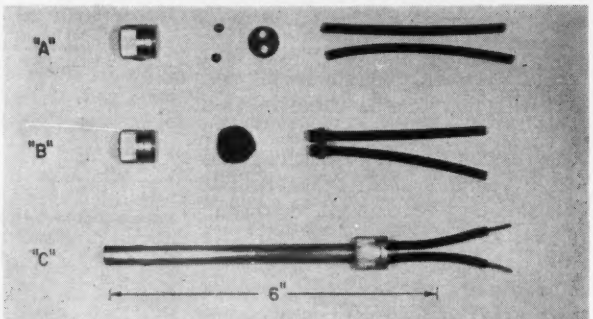
The recently issued Amendment 3 dated 29 April 1954 to Specification JAN-C-17A recognizes two types of coaxial cables employing mineral insulation. The specification covers cables for use at radio frequencies by the Armed Services. The two types, RG-81/U and RG-82/U, are suitable for continuous operation up to 250 C (482 F). The inner conductor of these cables consists of continuous uncoated solid copper wire and the outer sheath consists of continuous uncoated seamless copper tubing. Some of the important properties of these cables are:



CABLE SEAL TERMINATION AND GLAND

"A" Component parts of gland.
"B" Gland in place before tightening.
"C" Gland locked in finished position.

Figure 4. * * * * * * * * * * *

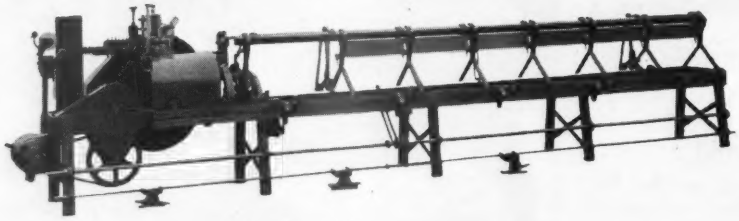


CABLE SEAL TERMINATION

"A" Component parts of assembly.
"B" Neoprene tubing mounted in insulating cap, sealing comp'd.
"C" Completed cable seal termination.

Figure 5. * * * * * * * * * * *

DOWNEY Single Loop Bale Tie Machine



FAMOUS FOR GENERATIONS
in production of long oval or old-fashioned round loops!

Designed for easy one-man operation
Capacity: 2000 Bale Ties per hour

- TIE LENGTHS: 5 to 15 feet. WIRE GAUGES: #12 to #16. Equipped with Master Unibrake Motor and Controls.
- Machine straightens wire, cuts to length, twists loop and counts finished ties at the rate of 35 per minute.
- Bundler equipment is conveniently attached to machine to spiral-wrap finished ties into bundles of 250 each.
- One man operating 1 or 2 machines completes entire manufacturing from putting wire on feed reel to taking finished bundle of bale ties from Bundler Attachment.

distributors:

SEYBOLD TRANSWORLD EXPORTERS
122 East 42nd Street, New York 17, N. Y. (USA)

	RG-81/U	RG-82/U
Nominal Capacitance, Micro-microfarads/Foot	37	36
Nominal Impedance, Ohms	52	52
Nominal Attenuation at 400 Megacycles/Second, db/100 Feet	4.3	2.9
Dielectric Strength, Min. Volts, RMS	3000	5000
Corona, Min. Volts, RMS	3000	5000
Overall Diameter, Inch	.375	.750

★ ★ ★

In addition to the above coaxial cables, mineral-insulated cables are used in both the coaxial and twin conductor form in radio frequency circuits where high temperatures and/or pressures are to be encountered.

Typical Installations

The neatness and simplicity of Type MI cable is illustrated by a typical installation shown in Figure 6. This figure shows the interconnection of limit switches and solenoid valves to a terminal box on a die casting machine where the cable is subjected to high temperatures. (The two risers at the right are hydraulic or pneumatic lines).

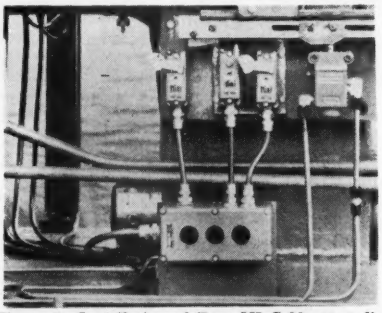


Figure 6. Installation of Type MI Cable on a die casting machine. * * * * * * * *

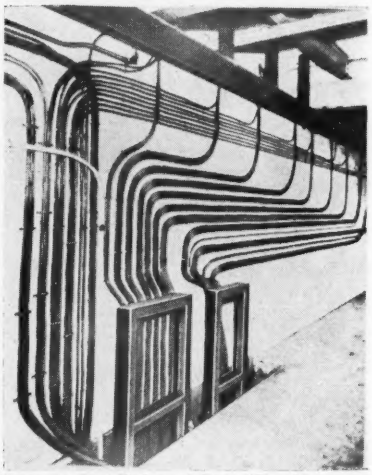


Figure 7. Installation of Type MI cable as control wiring in a large utility. * * * * *

A typical installation of Type MI cable used as control cable in a large utility is shown in Figure 7. Here again the neatness of appearance and simplicity of installation is apparent.

References:

1. Mineral-Insulated Metallic-Sheathed Cables, C. A. Jordan and G. S. Eager, Jr. American Institute of Electrical Engineers Power Apparatus and Systems, Number 17, April 1955, page 198.
2. Mineral-Insulated Metallic-Sheathed Conductors, F. W. Tomlinson and H. M. Wright, The Journal of the Institution of Electrical Engineers, vol. 98, Part II, No. 34, August 1946.

*Dr. Eager is a graduate of the Johns Hopkins University with the degrees of B. E. and Dr. Engr. During World War II, he was an officer with the U. S. Army Signal Corps. He joined General Cable Corporation in 1948 and is in charge of the development of low voltage power and communication products.

**S. P. Lamberton is a graduate of Brown University with the degree of Sc. B. in Electrical Engineering. During World War II, he was employed by the Signal Corps Engineering Laboratories in the Wire and Cable section, Fort Monmouth, N. J. He joined General Cable Corporation in 1945 as research engineer and is now research supervisor in the development of low voltage power and communication wires and cables.

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Solution Coating of Copper Wire

(*Continued from page* 1208)

stallation of this kind can be equipped with manual spray heads for fire protection and provided with suitable cleanouts for removal of the condensation. No provisions are made for the cooling of the hot wires except that which is obtained from the ambient air.

★ ★ ★

Arrangement #1 consists of a forced exhaust system and a forced air wire cooling system. By increasing the capacity of the exhaust fan approximately 300% over that which is required for furnace exhaust, sufficient air is handled in a direction counterflow to the wire travel. The furnace exhaust air is taken from the top of the furnace proper in the usual manner and the balance of cooling air is drawn through a narrow cooling zone in a counterflow direction to the wire travel. The cooling zone must be designed with due regard to smooth air flow.

★ ★ ★

Suitable water sprays for solids removal and a sludge tank is provided to settle out the enamel solids.

★ ★ ★

Method #4 consists of a counterflow air water scrubber which is used for the removal of the condensed solids and solvents in the exhaust air collected from the top of the furnace.

★ ★ ★

System #3 consists of an exhaust system employing a Catalytic Combustion incineration and heat recuperation system. These systems are especially advantageous on direct gas fired installations wherein the usable heat of the solvent released by its incineration is used for further heating and for maintenance of the furnace operating temperature.

★ ★ ★

Many communities are beginning intensive campaigns on the reduction of industrial stack effluents and larger installations in those areas must be given considerable scrutiny to prevent violations to health and air contamination codes.

★ ★ ★

Variations in different solvents produce some differences in the requirement of the exhaust load. A safe consideration in any case requires the removal of sufficient air to provide for the maintenance of a solvent vapor concentration of 25% of the lower explosive limit of the solvent being used. This is Insurance Code and National Board of Fire Underwriters' Code Requirements.

Temperature Requirements in the Preannealer

In consideration of the temperature requirements of the overall system, some statement should be made on the temperature requirements of the continuous wire preannealer as it is used in the enameling operation.

★ ★ ★

A typical annealer is shown in Fig. 14. Although it can be mounted elsewhere, it is invariably positioned over the takeup unit as shown in one of the previous slides.

★ ★ ★

There are several basic designs of in-process enameling annealers and the data that is shown on this slide has been taken from a straight pass annealer with a connected kilowatt input of 50 KW. The wire was exposed to operating temperatures of 1150°F. for 25 seconds. The atmosphere was super-heated steam and the pressure within the annealer was in the range of 3 to 5 lbs.

★ ★ ★

In determining the temperature shown in Fig. 15, thermocouples were placed at approximately 15" intervals throughout the annealer. When running 14 gauge wire, the atmosphere in the annealer assumed a temperature as shown by the solid black line. When running 12 gauge wire, the temperatures were as indicated by the broken line. In this case, the full bank of elements were operating under full "on" or "off" control.

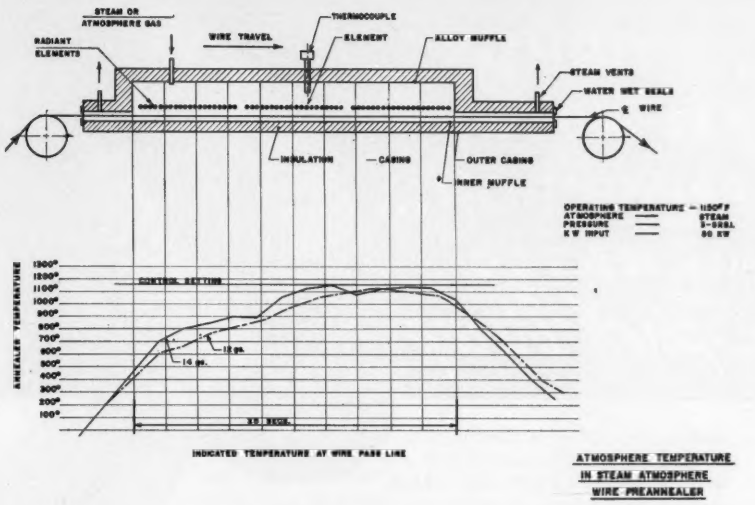
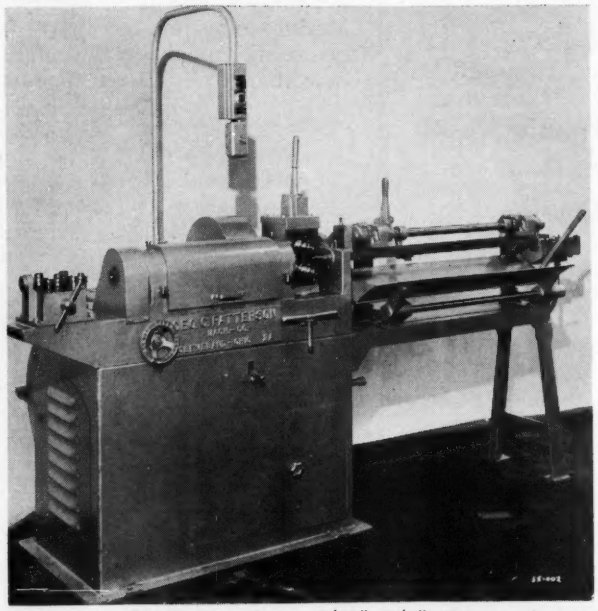


Figure 15

★ ★ ★

The position of the controlling thermocouple is shown and, although no data was taken with the wire passage stopped, there were other indications that the temperatures through the annealer were uniform to within plus or minus 25°F. The wire that was produced in this test exposure condition was of suitable ductility for the purpose for which it was intended.

★ ★ ★



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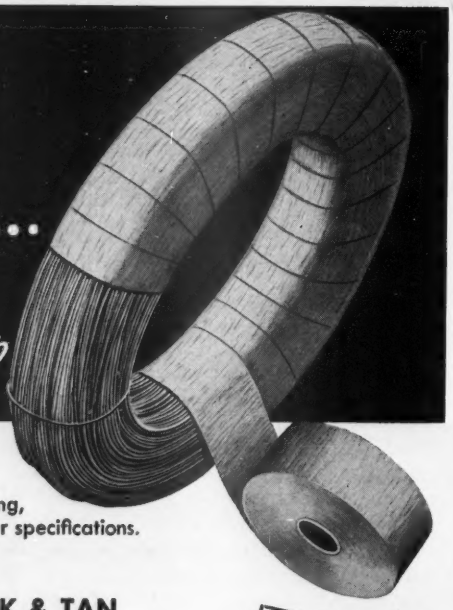

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It has been found from experience that the steam atmosphere annealer tends to produce a cleaner and smoother wire. This fact has been variously ascribed to the cleaning aspects of the superheated steam. The wiping of the wire by pressurized steam seals at either end of the annealer removes a considerable amount of copper dust and copper slivers.

★ ★ ★

After continued use, it has been found that the bottom of the annealer ahead of the exit seal contains small amounts of copper dust which again were apparently scoured or removed from the surface of the conductor. These copper slivers or dusts must be removed in the preannealing operation so they cannot be carried into the application system whereby they produce contamination of the solution coatings and eventual reduction of the electrical insulating value of the wire.

★ ★ ★

In conjunction with the annealing operation, it is many times feasible to provide roller straighteners either before or after annealing. It has been found that straightening of the wire after annealing produces a more uniform wire than straightening that same wire before annealing.

★ ★ ★

Conventional roll straighteners are used and if the straightening is accomplished after annealing, the offset deflections of the various straightening rolls can be appreciably less than if the straightening is done before annealing.

★ ★ ★

If the wire in any system is properly paid off, annealed, coated, fused and wound up, there is relatively no chance for the production of eccentrically coated wire or the production of wire that will be unable to meet exacting customers' specifications.

★ ★ ★

We trust that this review of the elemental problems and their solutions, as they are encountered in the design of precision wire coating equipment, has been interesting and informative to you.

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Progressive Work-Hardening and Reannealing of Five Brands of High Conductivity Copper

(*Continued from page* 1194)

In the manufacture of hot-tinned hard-drawn copper wire the pre-selection of copper having suitable high resistance to softening in the tin bath is essential to insure a consistently good product. In this case all of the essential information concerning the softening behavior is likewise contained in the progressive reannealing characteristics.

★ ★ ★

The General Cable Corporation has been employing the progressive reannealing technique for the determination of the softening behavior of copper for the last few years. It was found that evaluation, pre-selection and channeling of copper lots can be accomplished more readily, positively and quantitatively than by the older testing methods.

★ ★ ★

The T_3 temperatures given in Table 8 and Figure 15 are also valid for annealing that employs a soaking time. This follows from the fact that the annealing range is lowered not only by a lower rate of heating in progressive annealing but by employment of a longer holding time in isothermal annealing.

★ ★ ★

The material gathered by this investigation is of value for planning reduction and annealing sequences. Any numerical information for such purposes which concerns the brands studied is available in the appropriate tables and graphs. The demonstration of the presence of a hump in Figures 10, 12, 13, and 14 is of value in devising a processing schedule capable of producing an extremely ductile, fully soft, wire. As already indicated, such a schedule should exclude reduction higher than 75 percent between anneals. This limitation is, of course, valid only where extra high ductility is desired. A reduction of 90 percent is generally used in the copper industry during normal processing.

★ ★ ★

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Mill personnel who supervise hot-rolling of copper similar in composition to the brands tested here will find the T_3 temperature of immediate use. These indicate the very lowest finishing temperature for the product if full softness is specified.

Survey of the Findings From the Point of View of Research Metallurgists

The research metallurgist should be interested in every phase of this work. Of particular interest to him, however, should be the general approach which as has been already demonstrated, introduces apparently quite a few advantageous features. The tables and graphs in this paper adequately demonstrate the high degree of accuracy with which useful data which characterize work-hardening and reannealing of metals can be secured by this novel approach. The simplicity and accuracy of the techniques employed alone qualify this approach as, to say the least, satisfactory for many pressing research tasks. These may range from routine quality testing to fundamental studies of some fine details of the process of primary recrystallization. The rapidity with which the method can supply the reannealing data is extraordinary. To justify this adjective, it will be noted that all the reannealing runs and tests which yielded data presented in this paper consumed less than 100 man hours; that is, approximately 2 man hours per wire sample. An equally informative isochronal reannealing curve charted by the same number of points would require for completion definitely more than 20 man hours. This estimation indicates that reannealing characteristics can be secured by the new method in at least one-tenth of the time required by the commonly used isochronal method.

* * *

Metallurgists who investigate the enhancement of high or low thermal stability of work-hardened metals by 1) alloying, 2) alterations in processing schedules and 3) proper assignment of incoming

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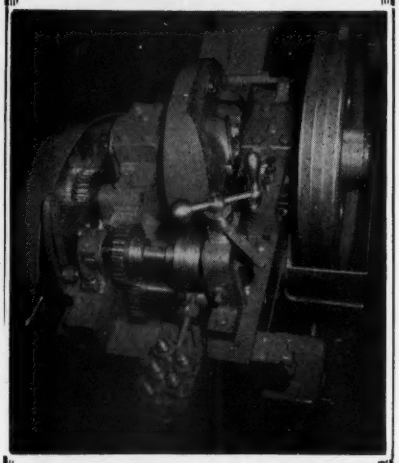

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heats of metals, as well as metallurgists who are responsible for the consistency of the desired degree of thermal stability, be it high or low, may find it very profitable to press this method into service.

Acknowledgments

The authors wish to thank Mr. J. S. Smart, Jr. of the American Smelting and Refining Company for his kindness in securing the high-purity copper from his organization.

Due appreciation is being expressed to the General Cable Corporation and in particular Messrs. S. A. Smith, R. W. Atkinson, L. Meyerhoff, and J. A. Szilard for supplying the commercial brands of copper and permitting one of the authors to freely use their plant and research facilities.

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New Electronic Spring Gauge

A new invention called the Winstrom Electronic Gauge for use on automatic spring coilers measures the tolerances on the free length of each spring as it is coiled and automatically accepts a correct spring and rejects and discards springs too short or too long. This new product has been used successfully for high quantity production in a spring plant in Connecticut for about one year to determine its accuracy and suitability. The instrument has proved itself and is now on the market for the first time.

★ ★ ★

It is now possible to eliminate expensive hand measuring the lengths of springs because this gauge provides 100% inspection at no extra cost of manufacture. Lengths can be held to plus or minus .001 in. if desired and springs can be made which previously were considered impossible.

★ ★ ★

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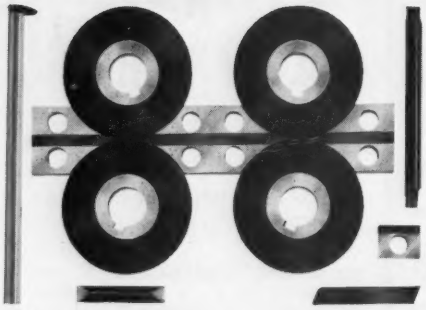

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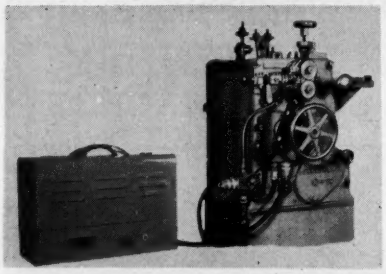

usual. A blast of air ejects springs that are too short or too long.

★ ★ ★

The gauge measures spring lengths from ⅛ in. to 4 in. as fast as they can be coiled, to any tolerance desired. A descriptive bulletin is available from The Carlson Company, 277 Broadway, New York 7, New York.

Outstanding Personalities of the Wire Industry

(*Continued from page* 1265)

Bick Appoints New Sales Representative

Hans C. Bick, Inc., Reading, Pa., well-known manufacturer of chemical specialties to the metal-working trades, has appointed **Melvin M. Chatfield** as sales and technical service representative, effective August 1. Mr. Chatfield has long been identified with the industry in various capacities and will continue to make his headquarters at his Philadelphia office.

Engle Joins Fansteel

Edgar W. Engle has joined the technical staff of **Fansteel Metallurgical Corporation** as assistant to the technical director, **Frank H. Driggs,** president of Fansteel, announces.

★ ★ ★

Since his graduation from Massachusetts Institute of Technology in 1941, Mr. Engle has been active in metallurgical engineering in the field of the refractory metals, their

carbides and alloys, and is generally recognized as one of the eminent men in this specialized field.

★ ★ ★

Mr. Engle is an active member of a number of technical societies, including the American Institute of Mining and Metallurgical Engineers, American Society for Testing Materials, American Society of Tool Engineers and American Ordnance Association.

Thomas C. Phillips

Thomas C. Phillips, vice president—sales of **Pittsburgh Steel Products Company,** succumbed to a heart attack on August 29th.

★ ★ ★

The 54-year-old sales executive was stricken while attending a conference in the Grant Building, headquarters for Pittsburgh Steel Products Co., a subsidiary of **Pittsburgh Steel Co.,** and died a few moments after collapsing in his chair. Mr. Phillips had served Pittsburgh Steel for 38 years, being made a vice president January 1, 1947.

E. Von Hambach

E. Von Hambach, nationally known pioneer in the development and fabrication of stainless steels, died at Reading on August 11th at the age of 62.

★ ★ ★

Mr. Von Hambach, a native of Chicago and long-time resident of Detroit, was research and development engineer for **The Carpenter Steel Company.**

★ ★ ★

During his 27 years' association with Carpenter, he had become one of the nation's foremost experts in the working of stainless steels and was known by many in the industry as "Mr. Stainless".

★ ★ ★

He was author of the handbook, "Notebook on Machining Stainless Steels," which was used widely and considered the most authoritative work on the subject. The book was based on his years of practical experience working with firms on

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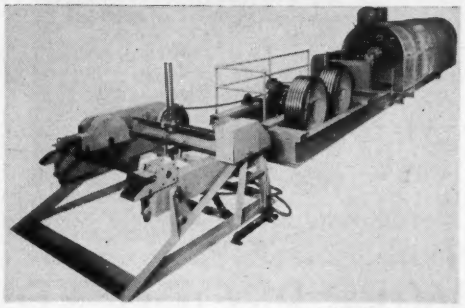

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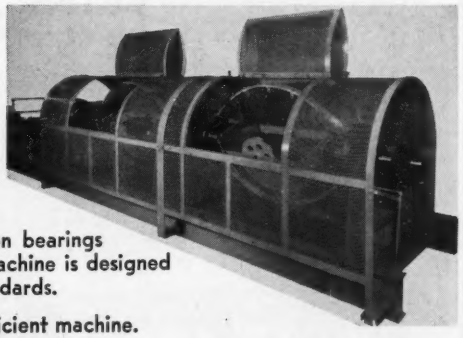
Cradle reels either 30", 36" or 48" in diameter.

Rotor speeds from 800 r.p.m. to 30 r.p.m. controlled by gear box and dual drive.



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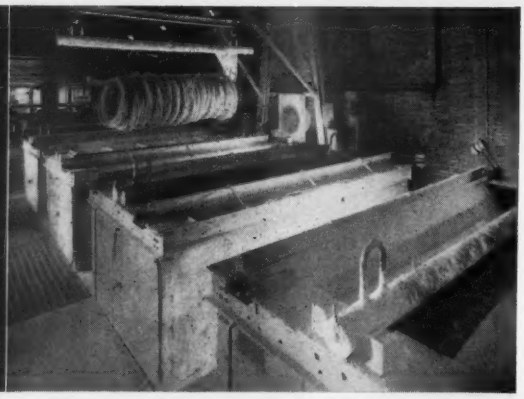

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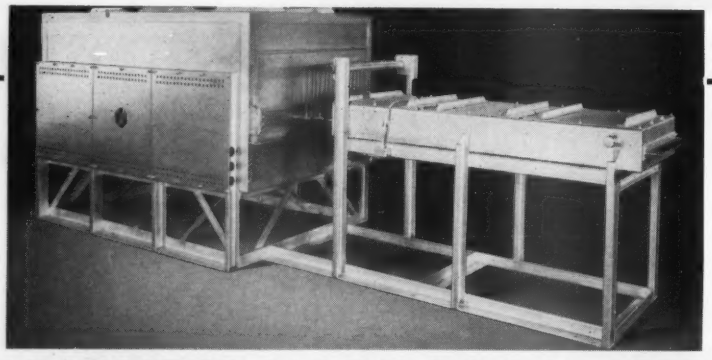

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Herbert J. French

Herbert J. French, Vice-President of **The International Nickel Company, Inc.,** and Assistant Vice-President of **The International Nickel Company of Canada, Limited,** died August 17, 1955 in Rochester, Minn., after an extended illness. He was 62 years old.

★ ★ ★

An outstanding metallurgist, Mr. French was the recipient of many distinguished technical awards for his contributions to the science of metallurgy.

★ ★ ★

He joined International Nickel in 1929 as a member of the metallurgical staff at the company's research laboratory at Bayonne, New Jersey. Two years later he was transferred to the company's Development and Research Division in New York City and placed in charge of alloy steel and iron development. In September, 1943, he was appointed Assistant Manager of the Division. Mr. French became Vice-President of The International Nickel Company, Inc., in March, 1947, and Assistant Vice-President of The International Nickel Company of Canada, Limited, in January, 1947.

Herbert Horsfall

Herbert Horsfall, seventy-six, president for many years of **Canada Wire & Cable Co., Ltd.,** and mayor of suburban Leaside from 1923 to 1930, died on August 20th. Surviving are his wife Lena Jane, and two sons, Douglas and Russell, all of Toronto.

Charles P. Gulick

Charles P. Gulick, seventy, chairman of the board and former president of the **Nopco Chemical Co.,** formerly National Oil Products Co., of Harrison, N. J., died September 4th at Dover General Hospital. He lived on Forest Way, Essex Fells, N. J.

★ ★ ★

Mr. Gulick was one of the

founders of the company, which was first carried on under the name of the National Red Oil & Soap Co., in 1907. He was president from 1932-'38, chairman of the board from 1939-'40, served in both posts until 1949 and as board chairman since that date.

★ ★ ★

Mr. Gulick once said that when the company started business "castor oil was the only product which had its origin in the mixing of oil and water." His firm pioneered in the development of similar sulphonated oils—a process that subjects oil to the action of chemicals—and developed more than 2,000 separate products, among which was a line of wire drawing lubricants.

★ ★ ★

Mr. Gulick was a former president and founder of the Sulphonated Oil Manufacturers Association.

Nopco Acquires Griffin Chemical

Announcement has been made by **Perc S. Brown,** Director and Vice President in charge of Nopco's Western operations, that **Nopco Chemical Company** has acquired the assets of the **Griffin Chemical Company** of San Francisco. Mr. Brown stated that this is the initial step in Nopco's planned further expansion by acquisition on the Pacific Coast.

★ ★ ★

Everett Griffin, who organized the Griffin Chemical Company in 1935, has guided its growth as a manufacturer of substantial tonnages of petroleum sulphonates, napthenic acid, emuslifiers, plasticizers, and polyvinyl acetate emulsion. He is highly regarded in West Coast business circles, and will be associated with Nopco at Richmond, California, in an executive capacity.

Reel Drive Selection

(*Continued from page* 1177)

in addition to the dancer roll, since the dancer roll cannot be accelerated rapidly enough to compensate for the difference in wire speed entering and leaving the dancer

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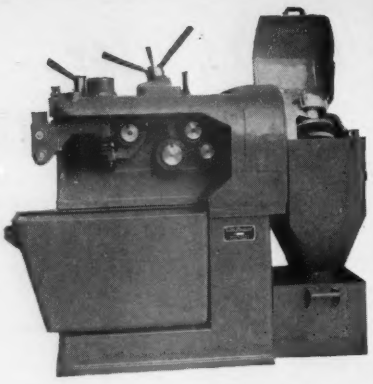

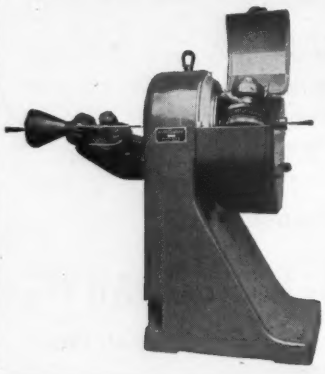

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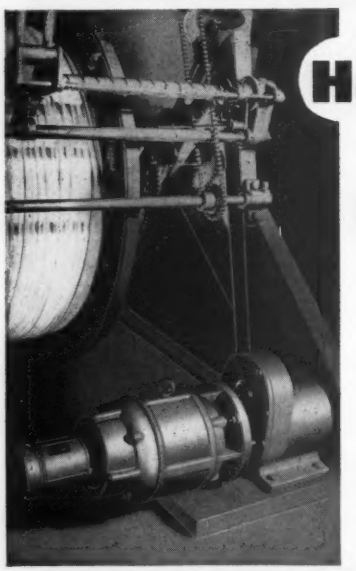

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loop. To avoid this instantaneous speed change, some installations have been made with separate motors for each reel. With this arrangement, the surface speed of the empty reel can be matched to the surface speed of the full reel. However, even here, careful design is required to be sure that the reel motor does not decelerate and reaccelerate too rapidly when the empty reel motor is transferred from speed control to dancer control.

Rheostat or Reactor for Dancer Control

Either rheostats or reactors may be used satisfactorily on almost all applications to obtain an electrical signal proportional to dancer roll position. Rheostats are more subject to mechanical wear than reactors, and require from 1/4 to 3/4 lb.-ft. torque to turn. Platetype industrial rheostats with separate bearings have been found very satisfactory for dancer roll service, but radio-type potentiometers usually require excessive maintenance. Reactors may require from 1/16 to 1/4 lb.-ft. torque to move through a cam, and it is necessary for the machinery builder to cut a cam to operate the reactor. Because it is very difficult to calculate and construct the cam with sufficient accuracy, shaping of the cam should be done empirically with all components of the drive in place. Due to these factors, the cost of installing a reactor will usually be higher than the cost of a rheostat. A reactor may be desirable if very low minimum tension is required, but in most cases additional loops of wire on the dancer will accomplish the same purpose.

★ ★ ★

Since an electronic, adjustable-voltage rectifier will always be required with a reactor but is not an essential component when a rheostat is used, the drive cost will frequently be higher when a reactor is selected. In most cases, either device may be used so that it is desirable for the wire machinery builder, or the wire manufacturer, to state the arrangement they prefer.

Some Basic Principles of Continuous Electroplating of Wire

(*Continued from page* 1166)

it by paddles or air streams are valuable in raising permissible current densities.

★ ★ ★

One of the benefits of drawing after plating is that the drawing operation can be relied upon to polish up a deposit even if it be rather matte in texture to begin with. This permits current densities to be used for plating which are higher than are permissible on wires which are plated at their finished size. Silver plated wire for decorative purposes in which a brilliant finish is quite necessary can be plated at current densities quite unsuitable for plating the final wire and the flat, milky deposit becomes highly polished in subsequent drawing.

★ ★ ★

Finally a useful formula is that which expresses the percentage by weight of coating on the finished wire. In precious metal plating the metal value of the coating is often a very appreciable fraction of the cost of the final wire and it is useful to be able to calculate this from the specification of the wire.

★ ★ ★

The accurate formula for the coating as a percentage by weight of the finished, drawn wire is:—

$$\frac{400t_1\,(d - t_1)\,\delta}{4t_1\,(d - t_1)\,\delta + (d - 2t_1)^2\,\delta_1} \text{ per cent}$$

★ ★ ★

This formula is exact and is true for any combination of diameter and coating thickness. It is, however, cumbersome and needlessly so for most coating purposes. It can be simplified by ignoring terms containing t_1^2 which is justifiable since d is generally of the order of .01 and δ of the order of .3, whereas t_1 is of the order of .00001. This simplification reduces it to:—

$$\frac{400\,t_1\,\delta}{4\,t_1\,\delta + (d - 4\,t_1)\,\delta_1} \text{ per cent}$$

(*Refer to Table for Values of K*)

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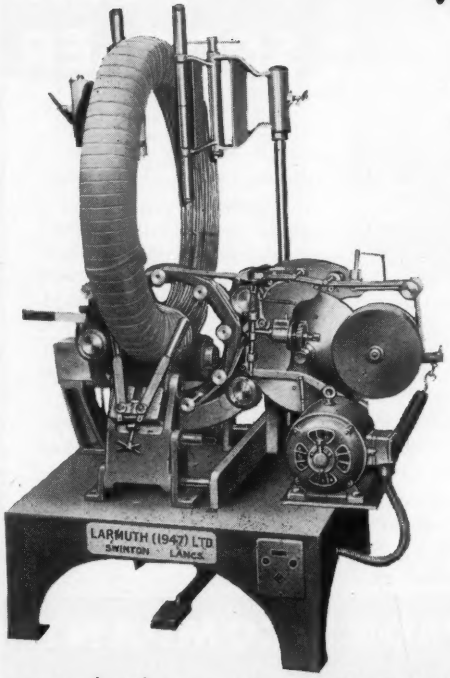

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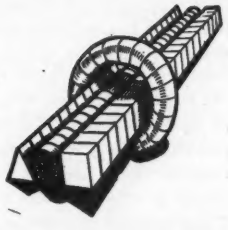

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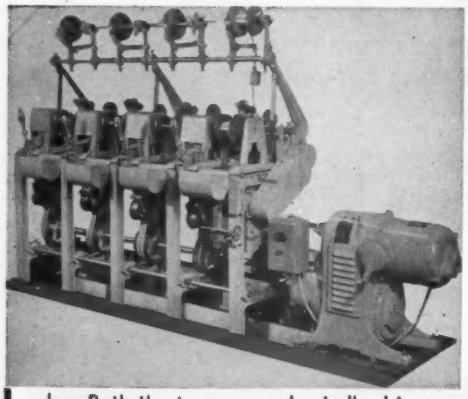

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Chrome Carbide for Hot Extrusion of Brass and Copper

(*Continued from page* 1231)

over 1200 billets and are still in service. Not only has this mill increased its production, but has improved its quality control standards over 30%.

★ ★ ★

To date, most material has been furnished as nibs only to the mills. Most mills have facilities and steel on hand for fabricating their present steel dies. Also, most mills have facilities for finishing and servicing their tungsten carbide drawing dies. Therefore, the most economical method of using this material is to purchase rough nibs and do your own mounting and finishing. Chrome Carbide is sold at approximately 70% of the cost of tungsten carbide and compares very favorably in price with special alloys used for hot extrusion.

★ ★ ★

As a matter of interest, chrome carbide has many other applications. Due to its coefficient of expansion, it is being widely used in the gage industry for "Jo blocks" and hoke blocks. Where a non-magnetic ball of low density is required, it is being used in many special instruments. Light weight fish rod guides are now being used extensively.

Folks who never do any more than they get paid for, never get paid for any more than they do.

To Head Research for Spencer Wire

Ralph Wohlforth, formerly with the **Kaiser Aluminum & Chemical Corp.,** Newark, Ohio, has joined the **Spencer Wire Corp.** at Union, N. J. as Director of Research Engineering. The appointment became effective on August 1st.

Tin-Zinc Alloy Plating, Its Application to Copper Wire

(*Continued from page* 1221)

flaking has taken place and the practical value of the coating has not been impaired. (The two large areas under the Scotch tape are inoculant.)

★ ★ ★

The conclusion can be drawn that tin-zinc alloy plating is far less susceptible to deterioration by the so called "tin pest" than is tin plating, and the improvement appears to be sufficient to permit the safe use of tin-zinc under extreme and continuous exposure to cold.

The Plating Process

The plating of tin-zinc alloy, 78% tin, is an established commercial process presently being operated in numerous plants both in America and England. All installations in the U.S.A. known to the authors are using the potassium modification of the original TRI process. (3). The bath has the following composition (oz/gal):

	Still Tanks	Barrels
Potassium stannate ..	16.0	12.7
Potassium hydroxide ..	0.9	1.3
Potassium cyanide	4.1	4.5
Zinc cyanide	1.4	1.8
Temperature	150°F	
Anodes	78/22 Tin/zinc alloy	

★ ★ ★

To plate wire, at the higher cathode current densities demanded, slight modification of the above composition was found to be desirable, leading to a bath of the following composition:

Potassium stannate	16.5 oz/gal
Potassium hydroxide	1.1 "
Potassium cyanide	4.9 "
Zinc cyanide	0.9 "
Temperature	200°F

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With this solution in the wire-plating machine previously described (1) copper wire was plated at speeds of 100-300 ft/min. The plating tank was 10 ft. long. Higher speeds of operation would be feasible in a longer tank. Other conditions, as cleaning, rinsing, drying, etc. are the same as for tin plating from the potassium stannate bath.

★ ★ ★

All experimental work was conducted in one 10 ft. long plating tank using number 18 B & S Gauge copper wire. Two arbitrary wire speeds of 100 and 300 ft. per minute were selected in most of the tests for the production of coatings of two different thicknesses or weights. Under these conditions it was possible to produce a thickness of 106 millionths of an inch at 100 feet per minute and 36 millionths at 300 feet per minute. Current density was approximately 2500 amperes per square foot.

★ ★ ★

The solution described above was found to be chemically stable under both storage and operating conditions. There was no excessive sludging of metal salts. The additions of potassium cyanide and potassium hydroxide to replace losses by decomposition were quite moderate. Maintenance of the proper concentrations of these two chemicals is important in order to secure deposits of the proper alloy composition and with the maximum efficiency. The metal concentrations are of considerably less importance. Fortunately, both the free potassium hydroxide and total potassium cyanide may be quickly and easily determined by simple titrations.

★ ★ ★

Deposits as thin as 14 millionths easily passed the standard ASTM dip test, thus demonstrating excellent continuity of coating. Adhesion and ductility were both of the highest order when the wire was subjected to a mandrel test by wrapping it around its own diameter. The wire also burnished quite satisfactorily when it was drawn through a die.

Summary and Conclusions:

It has been shown that the tin-zinc alloy (78% tin) possesses several advantages over pure tin in retention of solderability, corrosion resistance and freedom from the phase transformation known as "tin pest". The alloy plating process is well proven in commercial use, and although its application to the plating of copper wire in high speed continuous fashion is in the experimental stage, work has been carried far enough to indicate that no unusual problems will probably be encountered.

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(1) F. A. Lowenheim: Wire and Wire Products 27 464, 506 (1952); C. O. Bruestle, ibid. 27 565, 632 (1952)

(2) R. M. Angles, J. Electrodepositors' Tech. Soc. 21 45 (1946); J. W. Cuthbertson and R. M. Angles, J. Electrochemical Society 94 73 (1948)

(3) Technical Data Sheet No. 107. "The Plating of Tin-Zinc Alloys" Metal & Thermit Corporation, New York (1953); F. A. Lowenheim and R. M. MacIntosh, J. Electrodepositors' Tech. Soc. 27 115 (1951)

Factors Affecting the Characteristics of $CA(OH)_2$ In Suspension With Special Reference to the Wire Drawing Industry

(*Continued from page* 1218)

Our thanks are extended for the invaluable assistance which was provided by the mills cooperating in this study.

Ductility Tests for Electrical Conductors

(*Continued from page* 1211)

the supporting vertical steel straps contains a 4½ inch vertical ⅜ inch wide slot, covered with an adjustable plate to restrict the slot opening for wires with different diameters.

* * *

A six-inch steel mandrel having the same diameter as the test specimen is inserted and secured between the chucks. The opening in the steel strap has rounded edges which are greased prior to test to prevent any undue friction

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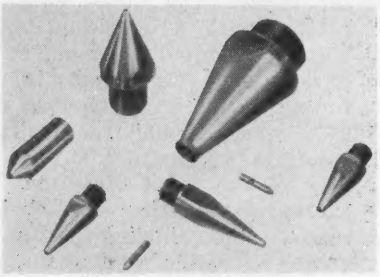

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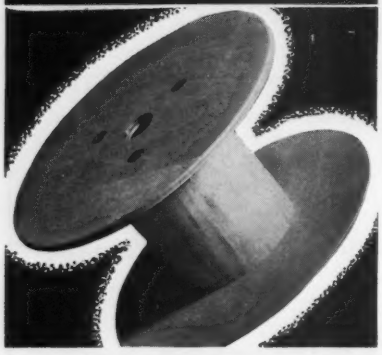

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caused by the wire passing through the steel mandrel. The test specimen is threaded through the slot in the strap and anchored at the ¼ inch hole in the flange of the lower chuck by means of an Allen set screw. The upper chuck is rotated with a precision torque wrench. Torque readings are recorded while the sample is uniformly wound helically at a rate of 2 r.p.m. around the mandrel. Readings are usually steady but may fluctuate for wires that are excessively brittle. For obvious reasons the starting torque is greater than the winding torque.

* * *

Figure 5 shows a general view of the torque-wrap tester with a specimen beginning the helical twist.

* * *

Figure 6, a bar chart, gives the average torque-wrap test results and the 90% probability limits of ten specimens tested.

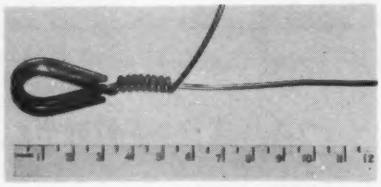

Fig. 6—Torque-wrap Tests

Wrap Back Test

The purpose of the wrap-back test is to determine the feasibility of wrap-back dead-ending single conductors or neutral/messenger conductors of multiplex cables. This test specifically indicates the ability of the conductor to be formed into a wrap-back dead-end, unwound, reformed and so on to failure.

* * *

A thimble suitable for the test specimen diameter is selected and clamped tightly in a vise. The center portion of a three-foot test specimen is wrapped around the thimble. One end is then helically wound around the other end for eight complete turns. The wires are then unwrapped, reasonably straightening the wire in the

5 ways better

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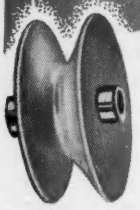

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process. Wrapping and unwrapping is continued until failure of the wire or until the wire becomes excessively kinked.

★ ★ ★

Figure 7 shows a simulated wrap-back dead-end of a sample of #4 AWG solid EC Aluminum.

★ ★ ★

Table 1 gives a comparison of wrap-back test results of wires used throughout the ductility tests.

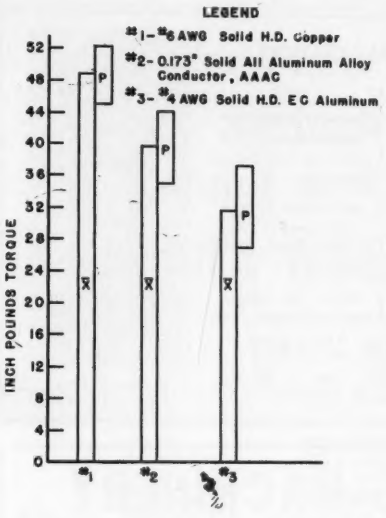

Fig. 7—Wrap-back Test * * * * * * * * *

TABLE I

DEAD-END WRAP-BACK TEST

#6 AWG Solid H D Copper.	Wrapped and unwrapped once excessive kinking
0 173" AWG Solid Aluminum Alloy Conductor, AAAC	Wrapped and unwrapped twice - broke third wrap on
#4 AWG Solid E C Aluminum:	Wrapped and unwrapped 3 times - broke fourth wrap on

Conclusion

The apparatus and tests described above have proven of great value in guiding our development of high strength, ductile aluminum wires for electrical conductors.

★ ★ ★

Although these test machines and techniques were specifically developed to apply to conductors, minor conversions of the equipment should produce useful tools in many phases of any type of wire manufacture.

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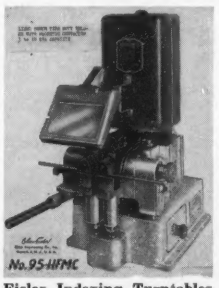

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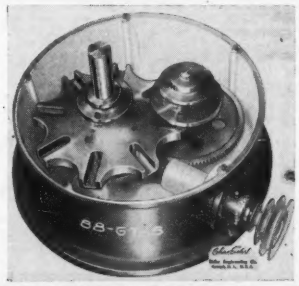

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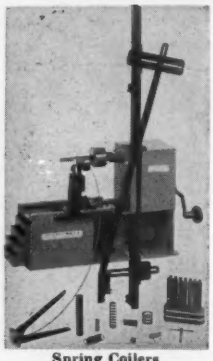

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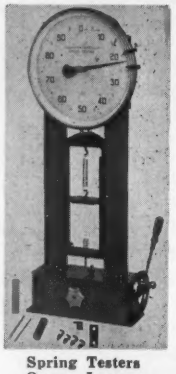

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Carris Reels Moves to Larger Quarters

Carris Reels, Inc., specialists in the design and manufacture of plywood reels and spools, has moved to new and larger quarters at 70 Park St., Rutland, Vermont, according to an announcement made by **President Henry Carris.**

★ ★ ★

To meet the increased demand with the utmost speed, the new plant is equipped for fastest possible materials handling, production and delivery. Among new facilities are lift trucks, an adjacent railroad siding, and a truck dock.

★ ★ ★

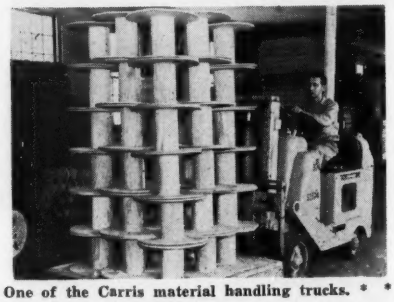
Increased space will allow the firm to increase volume, and efficient straight-line production methods assure high standards can be maintained along with low costs.

★ ★ ★

Mr. Carris emphasized that the combination of added space, modern production and improved shipping and delivery facilities, means better service for all the firm's customers, whether orders are large or small.

★ ★ ★

Carris Reels, Inc., makes both returnable and non-returnable reels, and manufacture to special requirements.



One of the Carris material handling trucks. * *

A Practical Psychological Approach to Quality Control

(*Continued from page* 1239)

4. After a reasonable amount of discussion, which was held to an hour or less, photographs of operations in a customer's plant and of products made from our wire were projected on a screen by an Opaque projector. These were explained or discussed as required.

5. **As a finale, a group of products made from our wire were passed around the group, allowing each member to handle and examine each item closely. This was an opportune time to stress various points previously discussed.**

★ ★ ★

The interest shown in these meetings was very gratifying and requests for further information on lubrications, dies and maintenance were expressed. Plans were immediately developed to satisfy this desire.

★ ★ ★

Conducting a meeting on wire drawing lubrications was an entirely different matter. All through these meetings, a special effort had been made to avoid any show of superior knowledge by the leaders.

Sessions on Lubrications

1. A complete background of experimental work was presented. Reasons for the search for new and better lubricants and the benefits derived from this experimenting were presented.

★ ★ ★

2. Certain job conditions were set up and samples of wire taken under these conditions were used to stimulate discussion.

★ ★ ★

3. Discussion of the various types of lubricants, their use and the end results were discussed at great length.

★ ★ ★

4. Finally, samples of each lubricant were passed around the group. A common paper cup was used for this purpose. The cups were filled and weighed. On the lid, the type of lubricant, weight and cost were posted. This was one method, though in a very small way, of presenting some of the cost problems.

Sessions on Dies

As many wire drawers expressed a desire for information on dies, our die room foreman, **James Mer-**

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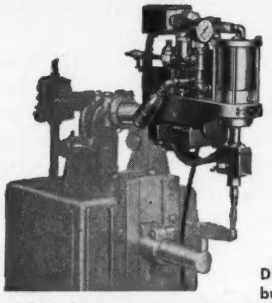

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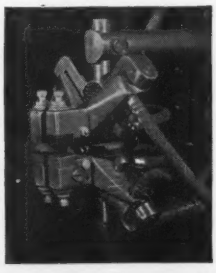

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rell, was requested to develop a program on dies. These meetings were entirely informational, although there was much discussion at the end of each meeting. The Opaque projector was used to assist in presenting an outline of the manufacturing processes used in making dies.

★ ★ ★

The flip chart was used to show the construction of the die and to discuss the various stages of die wear. Information on grades of carbide, drafting, entrance angles, etc., was presented.

★ ★ ★

Reasons for die failure and breakage were explained.

★ ★ ★

The good results of this program became obvious as it progressed.

★ ★ ★

The wire drawers requested that they be provided with more detailed information on customer requirements so as to enable them to produce the quality to meet specific requirements. Quality became the topic of the day among wire mill employees and immediate improvement occurred. Some of our less experienced employees began seeking advice from those with more experience and skill. Employees who had not yet attended a meeting requested that meetings be continued until they were given the opportunity to attend. The grievance man said that meetings such as these should have been started ten years ago. Union officials in other departments requested the same type of meeting be held in their departments. Fewer customer complaints were received. Employee attitudes were improved. Some employees said that they felt that meetings such as these tended to break down the wall between management and workmen. They felt more kindly toward management and the corporation as a whole.

★ ★ ★

The results obtained somewhat confirmed our belief that the work-

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"Manufacture and Properties Of Steel Wire"

A new book by Anton Pomp, Dr. Eng., translated from German into English by C. P. Bernhoeft, Dipl. Eng., and published by The Wire Industry, London, Eng. It contains 358 pages of text and sells for $11.80 per copy.

It is the most up-to-date treatise on steel-wire manufacture available and covers the latest developments in wire processing, such as mechanical descaling, increased drawing speeds and lubricants for these high speeds, die shapes and modern testing procedures. The entire range of wire manufacture, from rods to finished products are discussed.

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men already possessed the knowledge and skill required to solve many of our problems. The real problem was to get them to use this knowledge and skill to better advantage.

★ ★ ★

With this program we were able to establish a standard of quality in a very effective location, and that is in the minds of the workmen who produce our goods.

★ ★ ★

In a very short time the men who operate the equipment and produce the goods became interested in solving these problems. It was a challenge to their knowledge and skills and they accepted it. They realized that they were working with rather than for management, attempting to solve a problem common to all which no one wanted and which was a threat to their job security.

★ ★ ★

Because of our several months experience with this program we very definitely believe that it has opened the door to a practical method of enlisting the aid of the workmen for the improvement of not only the quality problem, but many other problems, such as cost, safety, etc. These programs, of course, are yet to be developed but we now have the tools and expect to use them to further advantage.

Wire Die Shape and Finish; Some Recent Developments in Production and Inspection

(*Continued from page* 1235)

undoubtedly speed the progress which is clearly in the making.

★ ★ ★

After the proper die shape and finish appears to have produced, it must be inspected. Two rather new devices have been developed by the British Iron and Steel Research Association, each serving a different purpose.

★ ★ ★

A Bore Profilograph has been developed which uses a probe together with an optical instrument

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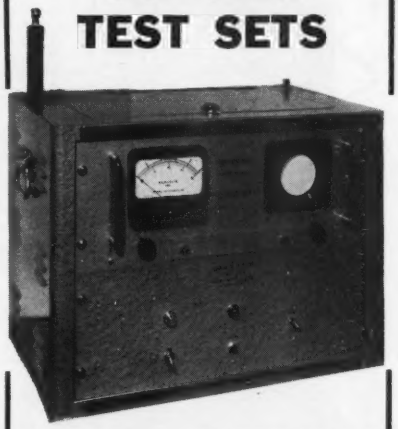

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—auto-collimator—to fully plot the contour of the die opening to .0001". This instrument is shown on Figure 7. It is not normally used for die sizes under .020". While a research tool rather than a production checking instrument, much is expected from its precise and permanent record of die shape and a semi-automatic recorder already existing will shortly be superseded by a fully automatic recorder.

★ ★ ★

The same British Iron & Steel Research Association has designed an instrument which I believe is rather similar to one originated in this country. The Profiloscope, as it is called, uses entirely optical principles as per Figure 8, unscored dies as well as die angles. (8A)

★ ★ ★

In Switzerland has been developed a microscope specially designed for diamond dies—Figure 9—which combines a particularly convenient arrangement of illumination with a device for holding the die so that defects can be quickly determined and also be readily marked.

★ ★ ★

Finally, Germany has produced a microscope which with a special eyepiece permits to conveniently and quickly compare tapers of sample pieces produced by pull-back against an angle scale and also length and diameter of the die's bearing. This shown on Figure 10.

★ ★ ★

To this has recently been added a roundness tester shown on Figure 11 which, now equipped with a projection screen, is said to permit quick and reliable check of die diameter in two 90° positions.

★ ★ ★

The scope of the subject is larger than I anticipated so I probably can only serve to stimulate the interest of those who feel that they need to know more and I am sure that any member will be most welcome to any further information which I might provide by referring them to sources which really know what I have been happy to talk about.

Drawing and Processing of Titanium Wire

(*Continued from page* 1247)

sulted in the "weak center" mentioned above after reduction to approximately 1/8" in size.

★ ★ ★

In the interim, the alloys were injected into the program. Rem-Cru A-110AT (Al-Sn Alloy) was to be required for welding and the C-130AM (Al-Mn Alloy) for use as fasteners.

★ ★ ★

Many new problems were presented by the higher strength, higher hardness and lower ductility. Consequently, as was expected, the reductions per pass and reductions between anneals were greatly reduced. Attempts to increase reductions resulted in heavy galling and breakage of the wire, or straining to the extent that "strain cracking" took place.

★ ★ ★

The same general experiences were encountered with alloys as with commercially pure. The same techniques which were successful for commercially pure also applied to the alloys.

★ ★ ★

We have been able to obtain reductions of 30 to 50% per pass and a total reduction of 75% between anneals at speeds over 100 ft. per minute.

★ ★ ★

Rem-Cru A-55 and A-110AT is now commercially available in sizes to 1/32" round in coils or level wound on spools for automatic welding.

★ ★ ★

Rem-Cru C-130AM is produced on a production basis in sizes down to 1/8" round in straight bar lengths, centerless ground finish.

★ ★ ★

Rem-Cru will also entertain orders in the A-55 grade for sizes under 1/32" round down to .020" round —level wound on spools or in coils, descaled and pickled finish.

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Stainless Steel Wire with Mirror-Like Finish Developed by National-Standard

A special stainless steel wire with a finish so lustrous and mirror-like that for many end-products subsequent finishing operations can be completely eliminated, has been developed by the **National-Standard Company,** Niles, Mich. The wire's natural finish requires neither plating nor coating, and for most applications costs no more than regular stainless steel wire.

* * *

Contrary to usual practice with stainless steel, this mirror-like wire without additional polishing is used in such products as auto radio antenna tips, safety pins, picnic grilles, forks and toys. It also is used in women's wearing apparel. For additional high lustre, where electro-polishing is used, this finish substantially reduces the time required for electro-polishing.

* * *

The mirror finish wire can be drawn from .030 to .090 of an inch and has a maximum tensile strength of 250,000 pounds per square inch. The only other wire with such finish is diamond-drawn, but it is not normally made in this range of sizes. The finish of the stainless steel wire is perfectly smooth, free from scratches or flaws, and is rounder than diamond-drawn wire.

* * *

This wire, to which National-Standard devoted nearly a year to develop, can be shipped in any quantity, either coiled or in straight lengths.

Morgan Construction Moving Some Facilities

The moving of more that 650 tons of equipment to its expanded plants on Crescent Street, from its main plant at Lincoln Square, a mile away, was completed in August, **Morgan Construction Company,** Worcester, Mass., rolling mill makers, has announced. The expansion cost $2,000,000.

* * *

To celebrate the removal, which does not mean abandonment of its Lincoln Square plant, Morgan held an open house, Oct. 10th, for all employes and their families.

* * *

Paul B. Morgan, Jr., treasurer, is in charge of the celebration.

* * *

The removal involved the tool room, expendable machine tool, shipping and receiving departments. The company has been using some Crescent Street facilities for many years. It is a 28-acre site. The addition included four construction bays, and more than 10,800 tons of steel were used in the expansion program for a building and additions to those already in use there.

* * *

The company also makes ejection stacks as chimney substitutes and has used these throughout.

* * *

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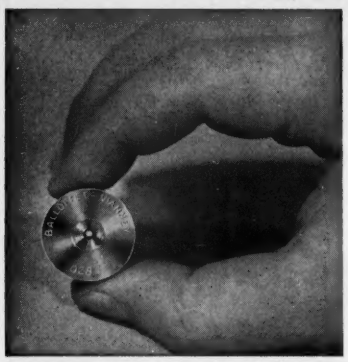

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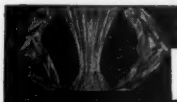

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The building at Lincoln square, where the company was started right after the Civil War, will continue as site of the forge, pattern, engineering, sales and other administrative and executive departments, but with expanded space.

Celanese to Build New Chemical Plant

Celanese Corporation of America will shortly begin construction of the first unit of a new chemical manufacturing plant at Gallipolis Ferry, West Va., it has been announced by **R. W. KixMiller,** vice president in charge of the Chemical Division of the company.

★ ★ ★

The new plant, to be built on the 412-acre land site purchased by the company in 1951, will produce plasticizers for the coatings and plastics industries; fire-retardant hydraulic fluids and compounds for the automotive, aircraft and other industries; and a range of intermediate products for general industry.

★ ★ ★

Celanese has the distinction of being the pioneer commercial producer of acetate yarns in the United States, having started operations in 1924 in Cumberland, Md. At present, the company has six other manufacturing plants serving the textile industry. These facilities are located at Narrows, Hopewell and Bridgewater, Va.; Rome, Ga.; Rock Hill, S. C., and Burlington, N. C.

★ ★ ★

Within the last year the company introduced two new fibers on the market—Arnel, a triacetate

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★ ★ ★

Plastics producing plants of the company turning out cellulose acetate films, sheets and compounds, polyethylene film, polyester resins and other products are located at Newark, Belvidere and Linden, all in New Jersey.

STATEMENT OF THE OWNERSHIP, management, and circulation required by the Act of Congress of August 24, 1912, as amended by the acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233), of WIRE AND WIRE PRODUCTS, published monthly at Jersey City, New Jersey, for year, 1955.

1. The names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Richard E. Brown, 453 Main Street, Stamford, Conn.; editor, Edmund D. Sickels, 453 Main Street, Stamford, Conn.; managing editor, none; general manager, Ruth S. Spengel, 453 Main Street, Stamford, Conn.

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5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and triweekly newspapers only.)

RUTH S. SPENGEL
Treas. & General Manager

Sworn to and subscribed before me this 15th day of September, 1954.

HAZEL R. RANDLETT
Notary Public
My commission expires April 1, 1958

Booklet on Tool Steels Available

Crucible Steel Company of America announces the availability of a newly-revised 44-page book entitled "Tool Steels for the Non-Metallurgist." Written to present a practical understanding of tool steels without being overly technical, the text is confined to direct, familiar phrases. It is intended to familiarize the nonmetallurgist with the six basic classifications of tool steels, enabling him to better handle the numerous grades within the general classifications.

★ ★ ★

Properties of the various types of tool steels are discussed and general recommendations are made as to which type of application is most suitable for each classification. The book points out that final choice of a tool steel should, of course, be determined by actual job experience.

★ ★ ★

In addition to a discussion of basic tool steel types, the book also discusses heat treating technique, and includes tables of pertinent information.

★ ★ ★

Copies of this booklet can be obtained by writing to the Advertising Department, Crucible Steel Company of America, P. O. Box 88, Pittsburgh 30, Pa.

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New Booklet Covers Strip Rolling Mills

A new, 8-page, Waterbury Farrel Bulletin describes and illustrates WF 2-High, Strip Rolling Mills for both ferrous and nonferrous operations such as breakdown, run down, planishing, tempering or skin pass rolling. The mills covered have roll diameters ranging from 5 inches to 24 inches.

★ ★ ★

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features described include rolls, bearings, housings, universal joints, gauge control, drive accessories and auxiliary equipment. Large, clear illustrations of six different sizes of mills are shown.

★ ★ ★

The back cover of the booklet lists other types of rolling mills and mill machinery as well as wire mill equipment, cold heading equipment and power presses built by the company.

★ ★ ★

Free copies of this new bulletin are available from **Waterbury Farrel Foundry & Machine Co.,** Waterbury 20, Conn. by asking for Circular No. 730-R.

New Scrubbers for Corrosive Fumes

Heil Process Equipment Corporation announces a new series of fume scrubbers designed specifically for cleaning acid and other corrosive fumes. Designated the 720 Series, they are particularly suited to pickling operations, electroplating process, and anodizing installations, or other corrosive fume producing systems.

★ ★ ★

Many advantages are available with the use of the 720 Series Fume Scrubber. Costly damage due to corrosion can be eliminated on plant buildings and employees' cars when fumes are discharged near a parking lot. General air pollution can also be eliminated, giving improved community relations.

★ ★ ★

For further information and literature, write Heil Process Equipment Corporation, 12901 Elmwood Ave., Cleveland 11, Ohio.

Triangle Conduit Adds to Facilities

Additional warehouse and manufacturing space is being added to the present wire mill of **Triangle Conduit & Cable Company, Inc.,** New Brunswick, N.J.

★ ★ ★

The addition will have a steel frame, brick and block walls and sprinklered construction. The roofing is built-up on a poured gypsum deck.

★ ★ ★

One side of the structure has a continuous loading dock for truck and rail shipping and receiving.

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A Company recently licensed by the Government of India intends to put up a complete plant for the manufacture of High Tensile Galvanized Steel Wire consisting of Wire Drawing Machines, Pickling, Patenting and Galvanizing baths. The annual capacity envisaged is 3000 tons on a three-shift operation basis. The wires to be produced will have 0.4 to 0.7 per cent carbon content. The size of the wire will vary from 0.059" to 0.186". It will be necessary for the supplier to arrange the training of technicians of the Indian Company in a plant manufacturing similar wire and using similar equipment. Interested manufacturers of the equipment involved, who can coordinate the supply of all the components are requested to contact. The Indian Company is also prepared to consider collaboration in the manufacture of the wire on a partnership basis with interested parties. Apply care of Box No. 820.

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453 Main Street Stamford, Conn.

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American Lanolin Corporation, Lawrence, Mass.
Apex Alkali Products Co., Philadelphia, Pa.
Rome Soap Manufacturing Co., Rome, N. Y.

COMPOUNDS—Rust Removing
American Chemical Paint Co., Ambler, Pa.
Apex Alkali Products Co., Philadelphia, Pa.
Magnuson Products Corporation, Brooklyn, N. Y.
Standard Industrial Compounds Co., Chicago.

COMPOUNDS—Vinyl, for Wire
Electronic Rubber Co., Stamford, Conn.
Monsanto Chemical Company, St. Louis, Mo.
Naugatuck Chemical Div., U. S. Rubber Co., New York, N. Y.

COMPOUNDS—Wire Drawing
Apex Alkali Products Co., Philadelphia, Pa.
Bick, Hans C., Inc., Reading, Pa.
Ironsides Co., The, Columbus, Ohio.
Magnuson Products Corporation, Brooklyn, N. Y.
Miller, R. H. Co., Inc., Homer, N. Y.
Nopco Chemical Co., Harrison, N. J.
Pacific Coast Borax Co., New York, N. Y.
Rome Soap Manufacturing Co., Rome, N. Y.
Standard Industrial Compounds Co., Chicago.
Swift & Company, Chicago, Ill.

CONDUCTORS—Flexible, Electrical
Montgomery Co., The, Windsor Locks, Conn.

CONTAINERS—Wire Packaging
(See DRUMS—Wire Packaging)

COPHOLDERS—Steel
Apco Mossberg Co., Attleboro, Mass.
Mossberg Pressed Steel Corp., Attleboro, Mass.
Wire & Textile Mach'y, Inc. (used) Pawtucket. R. I.

CORDS—Electrical, Tinsel Conductor
Montgomery Co., The, Windsor Locks, Conn.

COUNTERS—
(See MACHINERY—Measuring Wire and Cable)

CRANES—Wire Mill
Cleveland Tramrail Div. of the Cleveland Crane & Engineering Co., Wickliffe, O.
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

CUTTING TOOLS—Carbide
Carboloy Dept. of General Electric Co., Detroit.
Eastern Carbide Corp., New Rochelle, N. Y.
Firth Sterling, Inc., Pittsburgh, Pa.
Metal Carbides Corporation, Youngstown, Ohio
Vascoloy-Ramet Corp., Waukegan, Ill.
Willey's Carbide Tool Co., Detroit, Michigan.

CUTTING TOOLS—Wire
Porter, H. K. Inc., Somerville, Mass.
Robinson, M. W. Co., Rockfall, Conn.

DIAMONDS—Industrial
Balloffet-Vianney Wire Die Co., Inc., Guttenberg, N. J.
Molina-Straus Diamond Products Co., New York, N. Y.
Rusch Wire Die Corp., Croton-on-Hudson, N. Y.
Wayne Wire Die Co., Hillside, N. J.
Whittaker, Clark & Daniels, Inc., New York, N. Y.

DIAMOND POWDERS—
Danforth, The C. W. Co., Youngstown, Ohio
Elgin National Watch Co., Abrasives Div., Elgin, Ill.
Hyprez Div., Engis Equipment Co., Chicago, Ill.
Indiana Wire Die Co., Ft. Wayne, Ind.
Industrial Diamond Powders, Inc., Pittsburgh, Pa.
Kelly Wire Die Corp., New York, N. Y.
Molina-Straus Diamond Products Co., New York, N. Y.
National Research Company, St. Clair Shores, Mich.
New England Wire Die Co., Worcester, Mass.
Reinherz Co., J., Maywood, Ill.
Rusch Wire Die Corp., Croton-on-Hudson, N. Y.
Universal Wire Die Co., Cranford, N. J.
Wayne Wire Die Co., Hillside, N. J.
Whittaker, Clark & Daniels, Inc., New York, N. Y.

DIAMOND POWDER RECLAIMING—
Danforth, The C. W. Co., Youngstown, Ohio
Industrial Diamond Powders, Inc., Pittsburgh, Pa.
Kay & Warren Co., Brooklyn, N. Y.
Kelly Wire Die Corp., New York, N. Y.
National Research Co., St. Clair Shores, Mich.
Rusch Wire Die Corp., Croton-on-Hudson, N. Y.

DIAMOND TOOLS—
Indiana Wire Die Co., Ft. Wayne, Ind.
Metal Carbides Corporation, Youngstown, Ohio
Molina-Straus Diamond Products Co., New York, N. Y.
Universal Wire Die Co., Cranford, N. J.
Wayne Wire Die Co., Hillside, N. J.
Willey's Carbide Tool Co., Detroit, Michigan.

DIES—Carbide, Tungsten & Tantalum
Balloffet-Vianney Wire Die Co., Inc., Guttenberg, N. J.
Boulin, Victor J., Inc., New York, N. Y.
Carboloy Dept. of General Electric Co., Detroit.
Eastern Carbide Corp., New Rochelle, N. Y.
Firth Sterling, Inc., Pittsburgh, Pa.
Indiana Wire Die Co., Fort Wayne, Ind.
Kelly Wire Die Corp., New York, N. Y.
Metal Carbides Corp., Youngstown, O.
Rusch Wire Die Corp., Croton-on-Hudson, N. Y.
Universal Wire Die Co., Cranford, N. J.
Vascoloy-Ramet Corp., Waukegan, Ill.
Wayne Wire Die Co., Hillside, N. J.
Willey's Carbide Tool Co., Detroit, Michigan.

DIES—Cold Heading
Carboloy Dept. of General Electric Co., Detroit
Eastern Carbide Corp., New Rochelle, N. Y.
Firth Sterling, Inc., Pittsburgh, Pa.
Indiana Wire Die Co., Ft. Wayne, Ind.
Metal Carbides Corporation, Youngstown, Ohio
Vascoloy-Ramet Corp., Waukegan, Ill.
Willey's Carbide Tool Co., Detroit, Michigan.

DIES—Diamond
Ajax Industrial Supplies, Inc., Fort Wayne, Ind.
Balloffet-Vianney Wire Die Co., Inc., Guttenberg, N. J.
Boulin, Victor J., Inc., New York, N. Y.
Brenon, Inc., New Brunswick, N. J.
Cochaud Wire Die Inc., New York, N. Y.
Ft. Wayne Wire Die, Inc., Fort Wayne, Ind.
Indiana Wire Die Co., Ft. Wayne, Ind.
Kelly Wire Die Corp., New York, N. Y.
National Wire Die Co., New York, N. Y.
New England Wire Die Co., Worcester, Mass.
Rusch Wire Die Corp., Croton-on-Hudson, N. Y.
Universal Wire Die Co., Cranford, N. J.
Wayne Wire Die Co., Hillside, N. J.

DIES DIAMOND—Reversible
National Wire Die Co., New York, N. Y.

DIES—Extrusion
Carboloy Dept. of General Electric Co., Detroit.
Eastern Carbide Corp., New Rochelle, N. Y.
Firth Sterling, Inc., Pittsburgh, Pa.
Metal Carbides Corporation, Youngstown, Ohio
Rusch Wire Die Corp., Croton-on-Hudson, N. Y.
Universal Wire Die Co., Cranford, N. J.
Wayne Wire Die Co., Hillside, N. J.
Willey's Carbide Tool Co., Detroit, Michigan.

DIES—Eyelet
Eastern Carbide Corp., New Rochelle, N. Y.

DIES—Nail, Nail Cutters, Feeder Blocks, Grippers, etc.
Firth Sterling, Inc., Pittsburgh, Pa.
Pittsburgh Carbide Die Co., Monongahela, Pa.

DIES—Pointing
Sjogren Tool and Machine Co., Auburn, Mass.

DIES—Repairs & Re-Cutting
Ajax Industrial Supplies, Inc., Fort Wayne, Ind.
Balloffet-Vianney Wire Die Co., Inc., Guttenberg, N. J.
Boulin, Victor J., Inc, New York, N. Y.
Carboloy Dept. of General Electric Co., Detroit.
Cochaud Wire Die Inc., New York, N. Y.
Eastern Carbide Corp., New Rochelle, N. Y.
Ft. Wayne Wire Die., Inc., Fort Wayne, Ind.
Indiana Wire Die Co., Ft. Wayne, Ind.
Kelly Wire Die Corp., New York, N. Y.
Metal Carbides Corporation, Youngstown, Ohio
National Wire Die Co., New York, N. Y.
New England Wire Die Co., Worcester, Mass.

WHERE TO BUY, Continued

For more complete information, consult the annual Wire and Wire Products Buyers' Guide.

Rusch Wire Die Corp., Croton-on-Hudson, N. Y.
Universal Wire Die Co., Cranford, N. J.
Vascoloy-Ramet Corp., Waukegan, Ill.
Wayne Wire Die Co., Hillside, N. J.

DIES—Special Shapes, Etc.

Eastern Carbide Corp., New Rochelle, N. Y.
Firth Sterling, Inc., Pittsburgh, Pa.
Indiana Wire Die Co., Ft. Wayne, Ind.

DIES—Swaging

Sjogren Tool and Mach. Co., Inc., Auburn, Mass.

DIES—Tube Drawing

Balloffet-Vianney Wire Die Co., Inc., Guttenberg, N. J.
Carboloy Dept. of General Electric Co., Detroit.
Eastern Carbide Corp., New Rochelle, N. Y.
Firth Sterling, Inc., Pittsburgh, Pa.
Indiana Wire Die Co., Fort Wayne, Ind.
Kelly Wire Die Corp., New York, N. Y.
Metal Carbides Corp., Youngstown, O.
Rusch Wire Die Corp., Croton-on-Hudson, N. Y.
Vascoloy-Ramet Corp., Waukegan, Ill.
Willey's Carbide Tool Co., Detroit, Michigan.

DRAW BENCHES—

(See MACHINERY—Draw Benches)

DRUMS—Wire Packaging

Continental Can Company, Van Wert, Ohio

DRUMS & TRAVERSES—For Cable Reels

Entwistle, James L., Co., Providence, R. I.
Hubbard Spool Co., Garrett, Ind.
New York Engineering Co., Yonkers, N. Y.
Republic Steel Corp., Pressed Steel Div., Niles, Ohio

DRYING EQUIPMENT

Carl-Mayer Corp., The, Cleveland, Ohio
Industrial Ovens, Inc., Cleveland, Ohio.
Michigan Ovens, Inc., Detroit, Michigan.
Rockwell, W. S. Co., Fairfield, Conn.

ENGINEERS—Consulting

Lubricants—Hans C. Bick, Inc., Reading, Pa.
Wire Mill—Clarence S. Arms, Worcester, Mass.

EYELETS—Brass or Zinc

Platt Bros. & Co., The, Waterbury, Conn.

FENCING & FENCES—Wire

Nichols Wire and Aluminum Company, Davenport, Iowa.

FILM—Insulating

Standard Film Products Corp., Pawtucket, R. I.

FINISHERS—Flame Proof, for Wire

Carbro Chemical Co., Pawtucket, R. I.

FOAM PRODUCING COMPOUNDS—

American Chemical Paint Co., Ambler, Pa.
Parkin Chemical Co., The, Pittsburgh, Pa.

FURNACES—Brazing

Electric Furnace Co., Salem, Ohio
Rockwell, W. S. Co., Fairfield, Conn.

FURNACES—Galvanizing Equipment

Ajax Electric Co., Inc., Philadelphia, Pa.
Electric Furnace Co., Salem, Ohio
Rockwell, W. S. Co., Fairfield, Conn.
Wilson, Lee, Engr. Co., Cleveland, Ohio

FURNACES—Heat Treating

Ajax Electric Co., Inc., Philadelphia, Pa.
Carl Mayer Corp., The, Cleveland, Ohio
Drever Company, Bethayres, Pa.
Electric Furnace Co., Salem, Ohio
Rockwell, W. S., Co., Fairfield, Conn.
Wilson, Lee, Engr. Co., Cleveland, Ohio

FURNACES—Lead Melting

Electric Furnace Co., Salem, Ohio
Rockwell, W. S. Co., Fairfield, Conn.

FURNACES—Pot (oil, gas, electric)

Ajax Electric Co., Inc., Philadelphia, Pa.

FURNACES—Resistance Heating, Strand

(See Annealing Machines)

FURNACES—Salt Bath

Ajax Electric Co., Inc., Philadelphia, Pa.
Electric Furnace Co., Salem, Ohio
Rockwell, W. S. Co., Fairfield, Conn.

GAUGES—Wire Diameter, Continuous

Industrial Gauges Corporation, West Englewood, N. J.

GALVANIZING EQUIPMENT — (See MACHINERY—Galvanizing Wire)

GRINDERS—Roll

Norton Co., The, Worchester, Mass.

GUIDES—For Wire

Heany Industrial Ceramic Corp., New Haven, Conn.
Lignum-Viate Products Company, Jersey City, N. J.

GUIDE TIPS—For Extruding Machines (See NOZZLES)

HAMMERS—Nail Heading

Firth Sterling, Inc., Pittsburgh, Pa.
Pittsburgh Carbide Die Co., Monongahela, Pa.

HAMMERS—Swaging

Sjogren Tool and Machine Co., Auburn, Mass.

HARDSURFACING ALLOYS—

(See Alloys—Hardsurfacing)

HOOKS—Pickling & Liming

Lewis Welding and Engineering Corp., The, Bedford, Ohio
Youngstown Welding & Eng'g' Co., Youngstown, Ohio

HOISTS—Electric Travelling

Cleveland Tramrail Div. of the Cleveland Crane & Engineering Co., Wickliffe, Ohio

INHIBITORS—Pickling

American Chemical Paint Co., Ambler, Pa.
Apex Alkali Products Co., Philadelphia, Pa.
Parkin Chemical Co., The, Pittsburgh, Pa.

INSULATING MATERIALS—

Carbro Chemical Company, Pawtucket, R. I.
Celanese Corporation of America, New York, N. Y.
Chemical Products Co., E. Providence, R. I.
Electronic Rubber Co., Stamford, Conn.
Monsanto Chemical Co., St. Louis, Mo.
Naugatuck Chemical Div., U. S. Rubber Co., New York, N. Y.
Pittsburgh Plate Glass Company, Pittsburgh, Pa.
Standard Film Products Corp., Pawtucket, R. I.
Synthetic Thread Corporation, Bethlehem, Pa.

KETTLES—Galvanizing

National Annealing Box Co., Washington, Pa.

LACQUERING SYSTEMS — See MACH.—Lacquering Electric Wire

LACQUERS—For Electric Wire

Chemical Products Co., E. Providence, R. I.

LAGGING—Reel

North Anson Reel Co., No. Anson, Me.

LAME—LAHN—

Kassel Export Company, New York, N. Y.
Montgomery Co., The, Windsor Locks, Conn.

LIME—

Warner Co., The, Philadelphia and Bellefonte, Pa.

LUBRICANTS — For Metal Cutting, Stamping and Drawing

Apex Alkali Products Co., Philadelphia, Pa.
Magnuson Products Corporation, Brooklyn, N. Y.
Miller, R. H., Co., Inc., Homer, N. Y.
Nopco Chemical Co., Harrison, N. J.
Rome Soap Mfg. Co., Rome, N. Y.
Standard Industrial Compounds Co., Chicago.

LUBRICANTS—Wire Drawing

(See Compounds—Wire Drawing)

LUBRICANTS—Wire Rope

Swift & Co., Chicago, Ill.
Ironsides Co., The, Columbus, Ohio

LUBRICANTS—for Metal Cutting, etc.

Ironsides Co., The, Columbus, Ohio

MACHINERY—Armoring (Cable, Wire, Hose)

American Insulating Mach'y Co., Phila., Pa.
Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.
Wire & Textile Mach'y, Inc., (used), Pawtucket, R. I.

MACHINERY—Barbed Wire

Glader Wm., Machine Works, Chicago, Ill.
Wafios, Maschinenfabrik, Reutlingen, Wurtt., Germany

MACHINERY—Bending Wire

Eisler Engineering Co., Newark, N. J.

MACHINERY—Bobbin Winders

Mummert-Dixon Company, Hanover, Pa.
Wire Equipment Mfg. Co., Trenton, N. J.

MACHINERY—Braiding

Fidelity Machine Co., Inc., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Wardwell Braiding Mach. Co., Central Falls, R. I.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

MACHINERY—Bunching

Cook Manufacturing Co., The, Paterson, N. J.
Edmands Company, The, Providence, R. I.
Haskell-Dawes Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Niehaus, K. A., Maschinenfabrik, Dusseldorf-Rath, Germany
Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

MACHINERY—Bundling, Scrap

Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Cable, Electric

American Insulating Mach'y Co., Phila., Pa.
Fidelity Machine Co., Inc., Philadelphia, Pa.
Haskell-Dawes Machine Co. Philadelphia, Pa.
New England Butt Co., Providence, R. I.
New York Engineering Co., Yonkers, N. Y.
Niehaus, K. A., Maschinenfabrik, Dusseldorf-Rath, Germany
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Perth Amboy, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Capstans (See Machinery—Winding Wire)

MACHINERY—Centerless Grinding

Schumag Schumacher Metallwerke, Aachen Germany.

MACHINERY—Chain Making

Nilson, A. H. Machine Co., Bridgeport, Conn.
Wafios, Maschinenfabrik, Reutlingen, Wurtt., Germany

MACHINERY—Closing Rope

Niehaus, K. A., Maschinenfabrik, Dusseldorf-Rath, Germany
Watson Machine Co., Paterson, N. J.

MACHINERY—Coiling Rod

Vaughn Mach'y Co., Cuyahoga Falls, O.
Waterbury-Farrel Fdry. & Mach. Co., Waterbury, Conn.

MACHINERY—Cold Heading

Waterbury-Farrel Fdry. & Mach. Co., Waterbury, Conn.

MACHINERY—Copper Wire Drawing

American Insulating Mach'y Co., Phila., Pa.
National Mach'y Exch. (Used), New York.
Syncro Machine Co., Perth Amboy, N. J.
Torrington Mfg. Co., Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Fdry. & Mach. Co., Waterbury, Conn.

MACHINERY—Covering Wire (See MACHINERY—Insulating Wire)

MACHINERY—Cutting

Eisler Engineering Co., Newark, N. J.
Lewis Machine Co., The, Cleveland, Ohio
Mettler Machine Tool, Inc., New Haven, Conn.
Wells, Frank L., Co., Kenosha, Wis.

MACHINERY—Diameter Testing Continuous

Standard Electronic Research, New York, New York.

MACHINERY—Descaling Rod, Dry

Fisher Associates, New York, N. Y.
Herborn, Herborn, Germany.

MACHINERY—Die Making

Boulin, Victor J., Inc., New York, N. Y.
Carboloy Dept. General Electric Co., Detroit, Mich.
Dykrex Corp., Roos Tool & Mfg. Div., Newark, N. J.
Firth Sterling, Inc., Pittsburgh, Pa.
Wayne Wire Die Co., Hillside, N. J.

WHERE TO BUY, Continued

For more complete information, consult the annual Wire and Wire Products Buyers' Guide.

MACHINERY—Draw Benches
Morgan Construction Co., Worcester, Mass.
Torrington Mfg. Co., Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Edging (See MACHINERY — Tandem Rolling and Edging Mills)

MACHINERY—Enameling
American Insulating Mach'y Co., Phila., Pa.
Cook Manufacturing Co., The, Paterson, N. J.
Industrial Ovens, Inc., Cleveland, Ohio
Litzler, C. A., Co., Inc., Cleveland, Ohio.
Michigan Ovens, Inc., Detroit, Michigan
Rockwell Co., W. S., Fairfield, Conn.

MACHINERY—Extruding
Davis-Standard Sales Corp., Mystic, Conn.
Entwistle, James L., Company, Providence, R. I.
Modern Plastic Machinery Co., Lodi, N. J.
Royle, John, & Sons, Paterson, N. J.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

MACHINERY—Fence
Blashill and Company, Arthur, Worcester, Mass.
Glader, Wm., Machine Works, Chicago, Ill.

MACHINERY—Flat Wire
Fenn Manufacturing Co., Newington, Conn.
Mettler Machine Tool, Inc., New Haven, Conn.
Rockwell, W. S., Company, Fairfield, Conn.
Torrington Mfg. Co., Torrington, Conn.

MACHINERY—Forming Wire
Baird Machine Co., Stratford, Conn.
Nilson, A. H., Machine Co., Bridgeport, Conn.
Wafios, Maschinenfabrik, Reutlingen, Wurtt., Germany

MACHINERY—Galvanizing Wire
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.
Wilson, Lee, Engr. Co., Cleveland, Ohio

MACHINERY—Gang Winders
Entwistle, Jas. L. Co., Providence, R. I.
Syncro Machine Co., Perth Amboy, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Grinding
Norton Co., The, Worcester, Mass.

MACHINERY—Insulating Wire
American Insulating Mach'y Co., Phila., Pa.
Davis-Standard Sales Corp., Mystic, Conn.
Fidelity Machine Co., Inc., Philadelphia, Pa.
Litzler, C. A., Co., Inc., Cleveland, Ohio.
Michigan Ovens, Inc., Detroit, Michigan
Modern Plastic Machinery Company, Lodi, N. J.
New England Butt Co., Providence, R. I.
Pourtier Pere et Fils, Romainville (Seine), France
Royle, John & Sons, Paterson, N. J.
Syncro Machine Co., Perth Amboy, N. J.
Wardwell Braiding Mach. Co., Central Falls, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Knitting
Fidelity Machine Co., Inc., Philadelphia, Pa.

MACHINERY—Lacquering Electric Wire
American Insulating Mach'y Co., Philadelphia.
Cook Mfg. Co., The, Paterson, N. J.
Industrial Ovens, Inc., Cleveland. O.
Michigan Ovens, Inc., Detroit, Michigan

MACHINERY—Lock Washer
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Looms, Wire Weaving
Mummert-Dixon Co., Hanover, Pa.
Wafios, Maschinenfabrik, Reutlingen, Wurtt., Germany

MACHINERY—Material Handling
(See Material Handling Equipment)

MACHINERY—Measuring Wire & Cable
Davis Electric Company, Wallingford, Conn.
Durant Mfg. Co., Milwaukee, Wis.
Entwistle, James L., Company, Providence, R. I.
New England Butt Co., Providence, R. I.
Standard Mill Supply Co., Pawtucket, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Nail and Tack
Baird Machine Co., The Stratford, Conn.
Glader, Wm., Machine Works, Chicago, Ill.
National Mach'y Exch. (Used), New York, N. Y.
Seybold Transworld Exporters, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Wafios, Maschinenfabrik, Reutlingen, Wurtt., Germany

MACHINERY—Packaging Wire
Coulter & McKenzie Machine Co., Bridgeport, Conn.

MACHINERY—Pickling
Lewis Welding & Engineering Corp., The, Bedford, Ohio
Youngstown Welding & Eng'g Co., Youngstown, Ohio.

MACHINERY—Pin Making
Baird Machine Co., The, Stratford, Conn.

MACHINERY—Pointing
Morgan Construction Co., Worcester, Mass.
National Mach'y Exch. (Used). New York.
Scudder, E. J., Fdry. & Mach. Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Perth Amboy, N. J.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury Conn.

MACHINERY—Pumps for Molten Metal
Wire Equipment Mfg. Co., Trenton, N. J.

MACHINERY—Re-Spooling
Boyd & Sons Manufacturing Corp., Philadelphia, Pa.
Davis Electric Company, Wallingford, Conn.
Emory, Robert J., Co., Newark, N. J.
Federal Manufacturing Co., Wallingford, Conn.
Mummert-Dixon Co., Hanover, Pa.
National Mach'y Exch. (Used), New York.
Vaughn Machinery Co., Cuyahoga Falls, O.
Watson Machine Co., Paterson, N. J.
Wire Equipment Mfg. Co., Trenton, N. J.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

MACHINERY—Rod Mill
Fenn Manufacturing Co., Newington, Conn.
Morgan Construction Co., Worcester, Mass.
Nichols Wire and Aluminum Company, Davenport, Iowa.
Schumag Schumacher Metallwerke, Aachen, Germany

MACHINERY—Rolling Mill
Fenn Manufacturing Co., Newington, Conn.
Morgan Construction Co., Worcester, Mass.
Torrington Mfg. Co., Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Rubber Insulating
Davis-Standard Sales Corp., Mystic. Conn.
Litzler, C. A., Co., Inc., Cleveland, Ohio.
Modern Plastic Machinery Co., Lodi, N. J.
Royle, John & Sons, Paterson, N. J.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

MACHINERY—Serving
Fidelity Machine Co., Phila., Pa.
Pourtier Pere et Fils, Romainville (Seine), France
Wardwell Braiding Machine Co., Central Falls, R. I.

MACHINERY—Spark Testing
Davis Electric Company, Wallingford, Conn.
Entwistle, James L., Company, Providence, R. I.
Federal Manufacturing Co., Wallingford, Conn.
Modern Plastic Machinery Co., Lodi, N. J.
Peschel Electronics, Inc., New Rochelle, N. Y.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

MACHINERY—Spring Making
National Mach'y Exch. (Used), New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., Torrington, Conn.
Wafios, Maschinenfabrik, Reutlingen, Wurtt., Germany
Wells, Frank L., Co., Kenosha, Wisc.

MACHINERY—Staple
Nilson, A. H. Machine Co., Bridgeport, Conn.
Seybold Transworld Exporters, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Wafios, Maschinenfabrik, Reutlingen, Wurtt., Germany

MACHINERY—Straightening & Cutting
Continental Fdy & Machine Co., Medart Division, Pittsburgh, Pa.
Lewis Machine Co., The, Cleveland, Ohio
Mettler Machine Tool Co., New Haven, Conn.
National Mach'y Exch. (Used), New York, N. Y.
Wells, Frank L., Co., Kenosha, Wisc.

MACHINERY—Stranding
Haskell-Dawes Machine Co., Philadelphia, Pa.
Milton Machine Works, Inc., Milton, Pa.
New England Butt Co., Providence, R. I.
Niehaus, K. A., Maschinenfabrik, Dusseldorf-Rath, Germany
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Perth Amboy, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Swaging
Fenn Manufacturing Co., Newington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Take-Up and Pay-Out
American Insulating Mach'y Co., Phila., Pa.
Blashill and Company, Arthur, Worcester, Mass.
Davis Electric Company, Wallingford, Conn.
Davis-Standard Sales Corp., Mystic, Conn.
Entwistle, James L., Company, Providence, R. I.
Federal Manufacturing Co., Wallingford, Ohio
Fenn Manufacturing Co., Newington, Conn.
Industrial Ovens, Inc., Cleveland, Ohio
Litzler, C. A., Co., Inc., Cleveland, Ohio.
Modern Plastic Machinery Co., Lodi, N. J.
New York Engineering Co., Yonkers, N. Y.
Standard Mill Supply Co., Pawtucket, R. I.
Watson Machine Co., Paterson, N. J.
Wire Equipment Mfg. Co., Trenton, N. J.

MACHINERY—Taping
American Insulating Mach'y Co., Phila., Pa.
New England Butt Co., Providence, R. I.
Pourtier Pere et Fils, Romainville (Seine), France
Syncro Machine Co., Perth Amboy, N. J.
Watson Machine Co., Paterson, N. J.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

MACHINERY—Testing Magnet Wire Coatings for Pin Holes
Federal Manufacturing Co., Wallingford, Ohio
Peschel Electronics, Inc., New Rochelle, N. Y.

MACHINERY—Testing, Physical
Scott Testers, Inc., Providence, R. I.

MACHINERY—Tinning Wire
American Insulating Mach'y Co., Phila., Pa.
Cook Manufacturing Co., The, Paterson, N. J.
Syncro Machine Co., Perth Amboy, N. J.

MACHINERY—Tinsel Rolling Mills
American Insulating Mach'y Co., Phila., Pa.

MACHINERY—Trolley Wire
Torrington Mfg. Co., Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Tube Mill, Cold Drawing
Mettler Machine Tool, Inc., New Haven, Conn.

MACHINERY—Turks Head
Fenn Manufacturing Co., Newington, Conn.

MACHINERY—Twinning
(See Mach.—Bunching)

MACHINERY—Twisters, Wire
Cook Manufacturing Co., The, Paterson, N. J.
Davis Electric Company, Wallingford, Conn.
Edmands Company, The, Providence, R. I.
Haskell-Dawes Machine Co., Philadelphia, Pa.

MACHINERY—Used
National Machinery Exchange, New York, N. Y.
Wire & Textile Machy., Inc., Pawtucket, R. I.

MACHINERY—for Wire Welding
(See WELDERS—Butt and Spot)

MACHINERY—Winding Wire
Emory, Robert J., Newark, N. J.
Entwistle, James L., Company, Providence, R. I.
Fenn Manufacturing Co., Newington, Conn.
Mummert-Dixon Co., Hanover, Pa.
New England Butt Co., Providence, R. I.
Standard Mill Supply Co., Pawtucket, R. I.
Watson Machine Co., Paterson, N. J.
Wire Equipment Mfg. Co., Trenton, N. J.

WHERE TO BUY, Continued

For more complete information, consult the annual Wire and Wire Products Buyers' Guide.

MACHINERY—Wire Drawing
Cook Manufacturing Co., The, Paterson, N. J.
Coulter & McKenzie Machine Co., Bridgeport, Conn.
Fenn Manufacturing Co., Newington, Conn.
Herborn, Herborn, Germany
Morgan Construction Co., Worcester, Mass.
Morgardshammers Mek Verstads AB, Morgardshammer, Sweden
National Mach'y Exch. (Used), New York, N. Y.
Schumag Schumacher Metallwerke, Aachen, Germany
Scudder, E. J., Fdry. & Mach. Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Syncro Machine Co., Perth Amboy, N. J.
Vaughn Machinery Co., Cuyahoga Falls, Ohio
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Wire Forming
Baird Machine Co., The, Stratford, Conn.
National Mach'y Exch. (Used), New York, N. Y.
Nilson, A. H. Machine Co., Bridgeport, Conn.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Wire Rope
Milton Machine Works, Inc., Milton, Pa.
New England Butt Co., Providence, R. I.
Niehaus, K. A., Maschinenfabrik, Dusseldorf-Rath, Germany
Watson Machine Co., Paterson, N. J.

MACHINERY—Wrapping with Paper
Larmuth (1947) Ltd., Swinton, England
Terkelsen Machine Co., Boston, Mass.

MATERIAL HANDLING EQUIPMENT—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

NAIL TOOLING—Tungsten Carbide
Firth Sterling, Inc., Pittsburgh, Pa.
Pittsburgh Carbide Die Co., Monongahela, Pa.

NAILS—Wire
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Nichols Wire and Aluminum Company, Davenport, Iowa.
Sheffield Steel Corp., Kansas City, Mo.
Wickwire Brothers, Inc., Cortland, N. Y.

NIPPERS—Wire Cutting
Robinson, M. W. Co., Rockfall, Conn.

NOZZLES—For Extruding Machines
Wire Tool Div., Bridgeport Jig Boring Co., Bridgeport, Conn.

OVENS—Cable Lacquering and Enameling
American Insulating Mach'y Co., Phila., Pa.
Carl-Mayer Corp., The, Cleveland, Ohio
Industrial Ovens, Inc., Cleveland, Ohio
Litzler, C. A., Co., Inc., Cleveland, Ohio.
Michigan Ovens, Inc., Detroit, Michigan
Rockwell Co., W. S., Fairfield, Conn.

OVENS—Rod Bakers
Carl-Mayer Corp., The, Cleveland, Ohio

OVENS—Welding Rod Coating
Carl-Mayer Corp., The, Cleveland, Ohio
Industrial Ovens, Inc., Cleveland, Ohio
Litzler, C. A., Co., Inc., Cleveland, Ohio.

PAINT BONDING CHEMICALS—
American Chemical Paint Co., Ambler, Pa.

PAINTS—Heat Resisting
American Chemical Paint Co., Ambler, Pa.

PANS—Spelter, Galvanizing, Lead
National Annealing Box Co., Washington, Pa.

PAPER—Creped Wrapping
Arkell Safety Bag Company, New York, N. Y.
National Waterproof Papers, Inc., Beverly, N. J.
Terkelsen Machine Co., Boston, Mass.

PAPER—For Coil Wrapping and Corrosion Prevention
Arkell Safety Bag Company, New York, N. Y.
National Waterproof Papers, Inc., Beverly, N. J.
Terkelsen Machine Co., Boston, Mass.

PATENT ATTORNEYS—
Lancaster, Allwine & Rommel, Washington, D. C.

PAY-OUT SYSTEMS—
(See MACHINERY—Take-Up & Pay-Out)

PHOSPHATE COATING CHEMICALS
(See COMPOUNDS—Phosphate Coating)

PICKLING COMPOUNDS—
See (Inhibitors—Pickling)

PICKLING—Hooks, etc. Acid Resisting
Lewis Welding and Engineering Corp., The, Bedford, Ohio
Youngstown Welding & Eng'g Co., Youngstown, Ohio

PICKLING TANK LININGS—
Chemsteel Construction Co., Inc., Pittsburgh, Pa.
Haveg Corp., Newark, Del.

PIPES & FITTINGS—Acid Resistant
Haveg Corp., Newark, Del.

PLASTICIZERS—
Celanese Corporation of America, New York, N. Y.
Monsanto Chemical Co., St. Louis, Mo.
Naugatuck Chemical Div., U. S. Rubber Co., New York, N. Y.

PLASTICS—for Wire Insulation
Carbro Chemical Co., Pawtucket, R. I.
Celanese Corporation of America, New York, N. Y.
Electronic Rubber Co., Stamford, Conn.
Monsanto Chemical Co., St. Louis, Mo.
Naugatuck Chemical Div., U. S. Rubber Co., New York, N. Y.

POTS—Lacquer
Industrial Ovens, Inc., Cleveland, Ohio

POTS—Wire Tinning
National Annealing Box Co., Washington, Pa.

PULLERS AND GRIPS—For Wire
Morgan Construction Co., Worcester, Mass.
Scudder, E. J. Fdry. & Mach. Co., Trenton, N. J.
Sjogren Tool and Machine Co., Auburn, Mass.
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, Ohio

PUMPS—Molten Metal
Fisher Associates, New York, N. Y.

REEL AND TENSION STANDS—
Davis Electric Company, Wallingford, Conn.
Fidelity Machine Company, Inc., Philadelphia
Industrial Ovens, Inc., Cleveland, Ohio.
New York Engineering Co., Yonkers, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Standard Mill Supply Co., Pawtucket, R. I.
Syncro Machine Co., Perth Amboy, N. J.
Watson Machine Co., Paterson, N. J.

REEL CRUTCHES—
Watson Machine Co., Paterson, N. J.

REELS & SPOOLS—Aluminum Alloy
Acrometal Products, Inc., Minneapolis, Minn.
Hubbard Spool Co., Garrett, Ind.
Milton Machine Works, Inc., Milton, Pa.
Muncy Valley Industries, Inc., Muncy Valley, Pa.
Wardwell Braiding Machine Co., Central Falls, R. I.

REELS & SPOOLS—Annealing and Stranding
Acrometal Products, Inc., Minneapolis, Minn.
Apco Mossberg Co., Attleboro, Mass.
Hubbard Spool Co., Garrett, Ind.
Milton Machine Works, Inc., Milton, Pa.
Mossberg Pressed Steel Corp., Attleboro, Mass.
Muncy Valley Industries, Inc., Muncy Valley, Pa.
Republic Steel Corp., Pressed Steel Div., Niles, Ohio

REELS—Metal Bound
Durkee Mfg. Co. Inc., Pine River, Minn.
Hubbard Spool Co., Garrett, Ind.
McCaskie, Inc., Wm., Westport, Mass.
North Anson Reel Co., No. Anson, Me.
Strand-Buffalo Corporation, North Tonawanda, N. Y.

REELS—Plywood
Carris Reels, Inc., Rutland, Vt.
Hubbard Spool Co., Garrett, Ind.
McCaskie, Inc., Wm., Westport, Mass.
Nelson Company, The, Baltimore, Md.
Strand-Buffalo Corporation, North Tonawanda, N. Y.

REELS & SPOOLS—Steel (All Types)
Acrometal Products, Inc., Minneapolis, Minn.
Apco Mossberg Co., Attleboro, Mass.
Clark, J. L. Mfg. Co., Rockford, Ill.
Hubbard Spool Co., Garrett, Ind.
Mason Can Company, East Providence, R. I.
Milton Machine Works, Inc., Milton, Pa.
Mossberg Pressed Steel Corp., Attleboro, Mass.
New York Engineering Co., Yonkers, N. Y.
Republic Steel Corp., Pressed Steel Div., Niles, Ohio
Wardwell Braiding Machine Co., Central Falls, R. I.

REELS—Wire Mill
Acrometal Products, Inc., Minneapolis, Minn.
Apco Mossberg Co., Attleboro, Mass.
Bridge Mfg. Co., The, Hazardville, Conn.
Carris Reels, Inc., Rutland, Vt.
Durkee Mfg. Co. Inc., Pine River, Minn.
Hubbard Spool Co., Garrett, Ind.
Mason Can Company, East Providence, R. I.
McCaskie, Inc., Wm., Westport, Mass.
Mettler Machine Tool, Inc., New Haven, Conn.
Milton Machine Works, Inc., Milton, Pa.
Mossberg Pressed Steel Corp., Attleboro, Mass.
New York Engineering Co., Yonkers, N. Y.
Nilson, A. H. Machine Co., Bridgeport, Conn.
North Anson Reel Co., No. Anson, Me.
Republic Steel Corp., Pressed Steel Div., Niles, Ohio
Wardwell Braiding Machine Co., Central Falls, R. I.

REELS & SPOOLS—Wood
American Woodworking Co., Chicago, Ill.
Bridge Mfg. Co., The, Hazardville, Conn.
Carris Reels, Inc., Rutland, Vt.
Durkee Mfg. Co. Inc., Pine River, Minn.
Hubbard Spool Co., Garrett, Ind.
Muncy Valley Industries, Inc., Muncy Valley, Pa.
Nelson Company, The, Baltimore, Md.
North Anson Reel Co., No. Anson, Me.
Strand-Buffalo Corporation, North Tonawanda, N. Y.

REFRACTORIES—High Temperature
Norton Company, Worcester, Mass.

RETORTS—Annealing
National Annealing Box Co., Washington, Pa.

ROD BAKERS—
(See OVENS—Rod Bakers)

RODS—Stainless Steel
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Crucible Steel Co. of America, Pittsburgh, Pa.
Pittsburgh Steel Co., Pittsburgh, Pa.

RODS—Wire—Non-Ferrous
Chase Brass & Copper Co., Waterbury, Conn.
Kaiser Aluminum & Chemical Corp., Oakland, Calif.
Platt Bros. & Co., The, Waterbury, Conn.
Scovill Mfg. Co., Waterbury, Conn.
Titan Metal Manufacturing Co., Bellefonte, Pa.

RODS—Steel
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Bethlehem Steel Co., Bethlehem, Pa.
Colorado Fuel and Iron Corporation, Pacific Coast Division, Oakland, Calif.
Continental Steel Corp., Kokomo, Ind.
Crucible Steel Co. of America, Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Sheffield Steel Corp., Kansas City, Mo.
Youngstown Sheet & Tube Co., Youngstown, O.

ROLLS—Wire Straightening
Lignum-Vitae Products Corp., Jersey City, N. J.

ROPE—Wire
Bethlehem Steel Co., Bethlehem, Pa.
Roebling's, John A. Sons Corp., Trenton, N. J.

RUST PROOF COMPOUNDS—
(See COMPOUNDS—Rust Preventing)

RUST REMOVING COMPOUNDS—
(See COMPOUNDS—Rust Preventing)

SATURANTS—Cable
Carbro Chemical Company, Pawtucket, R. I.

SATURATION SYSTEMS—
Industrial Ovens, Inc., Cleveland, Ohio
New York Engineering Co., Yonkers, N. Y.
Watson Machine Co., Paterson, N. J.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

SHEAVES—Wood
Lignum-Vitae Products Corp., Jersey City, N. J.

SOAPS—Industrial and Wire Drawing
(See COMPOUNDS—Wire Drawing)

SPOOLS—(See Reels & Spools)

SPOOLS—Stamped Metal for Retail Wire Sales
Clark, J. L. Mfg. Co., Rockford, Ill.
Mason Can Co., East Providence, R. I.

STAMPINGS—Steel
Acrometal Products, Inc., Minneapolis, Minn.
Mossberg Pressed Steel Corp., Attleboro, Mass.

STRIP—Steel
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
Roebling's, John A. Sons Corp., Trenton, N. J.
Youngstown Sheet & Tube Co., Youngstown, O.

WHERE TO BUY, Continued

For more complete information, consult the annual Wire and Wire Products Buyers' Guide.

TANKS—Compound
National Annealing Box Co., Washington, Pa.
New York Engineering Co., Yonkers, N. Y.
Watson Machine Co., Paterson, N. J.

TANKS—Pickling and Plating
Chemsteel Construction Co., Inc., Pittsburgh, Pa.
National Annealing Box Co., Washington, Pa.

TESTERS — INSULATION
(See MACHINERY—Spark Testers)

TESTING EQUIPMENT
(See MACHINERY Testing, Physical and Diameter Testing)

TINSEL—Electric Conductor
Kassel Export Company, New York, N. Y.
Montgomery Co., The, Windsor Locks, Conn.

TINSEL WIRE—Resistance, Lame, Decorative Cords Thread—Bare Copper, Silver and False Gold Coated, etc.
(See TINSEL—Electric Conductor)

TOOLS—Nail Machine
Pittsburgh Carbide Die Co., Monongahela, Pa.
Wire Equipment Mfg. Co., Trenton, N. J.

TOOLS—Wire Cutting
Porter, H. K. Inc., Somerville, Mass.

TOOLS—Spring Forming, Carbide
Crafts, Arthur A., Company, Inc., Boston, Mass.

TRAMRAIL SYSTEMS—
Cleveland Tramrail Div. of the Cleveland Crane & Engineering Co., Wickliffe, O.

TRANSMISSIONS—Variable speed (See Machy—Power Transmission)

TRAVERSES & DRUMS—For Reels
(See Drums & Traverses)

TRAVERSE MECHANISMS—
Apco Mossberg Co., Attleboro, Mass.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.
Wire & Textile Mach'y, Inc. (used) Pawtucket, R. I.

VALVES & FITTINGS—Acid Resistant
Haveg Corp., Newark, Del.

VARNISHES & LACQUERS—for Electric Wire
Carbro Chemical Co., Pawtucket, R. I.
Chemical Products Co., E. Providence, R. I.

VULCANIZING PANS AND EQUIPMENT—
American Insulating Mach'y Co., Phila., Pa.
Litzler, C. A., Co., Inc., Cleveland, Ohio.
Mossberg Pressed Steel Corp., Attleboro, Mass.

WELDERS—Spot and Butt
Eisler Engineering Co., Newark, N. J.
Micro Products Co., Chicago, Ill.

WIRE—Aluminum
Kaiser Aluminum & Chemical Corp., Oakland, Calif.
Malin & Co., The, Cleveland, Ohio
National Standard Company, Niles, Mich.
Nichols Wire and Aluminum Company, Davenport, Iowa.
Scovill Mfg. Co., Waterbury, Conn.

WIRE—Barbed
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.

WIRE—Brass and Bronze
Chase Brass & Copper Co., Waterbury, Conn.
Jury's Wire Products, Inc., Bloomfield, N. J.
Scovill Mfg. Co., Waterbury, Conn.
Spencer Wire Corp., Union, N. J.
Titan Metal Manufacturing Co., Bellefonte, Pa.

WIRE—Brush
Spencer Wire Corp., Union, N. J.

WIRE—Bunched & Stranded, Copper
Camden Wire Co., Camden, N. Y.
Utica Wire Corp., Derby, Conn.

WIRE—Cast
Youngstown Sheet & Tube Co., Youngstown, O.

WIRE—Cold Heading
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Bethlehem Steel Co., Bethlehem, Pa.
Camden Wire Co., Camden, N. Y.
Chase Brass & Copper Co., Waterbury, Conn.
Colorado Fuel and Iron Corporation, Pacific Coast Division, Oakland, Calif.
Continental Steel Corp., Kokomo, Ind
Crucible Steel Co. of America, Pittsburgh, Pa.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
Kaiser Aluminum & Chemical Corp., Oakland, Calif.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Scovill Mfg. Co., Waterbury, Conn.
Sheffield Steel Corp., Kansas City, Mo.
Titan Metal Manufacturing Co., Bellefonte, Pa.
Wickwire Steel Div., The Colorado Fuel & Iron Corp., New York, N. Y.
Youngstown Sheet & Tube Co., Youngstown, O.

WIRE—Copper
Camden Wire Co., Inc., Camden, N. Y.
Chase Brass & Copper Co., Waterbury, Conn.
Jury's Wire Products, Inc., Bloomfield, N. J.
Spencer Wire Corp., Union, N. J.
Utica Wire Corp., Derby, Conn.

WIRE—For Electrical Conductors
Camden Wire Co., Camden, N. Y.
Kaiser Aluminum & Chemical Corp., Oakland, Calif.

WIRE—Flat, Fine
Kassel Export Co., New York, N. Y.
Montgomery Co., The, Windsor Locks, Conn.

WIRE—Galvanized
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Colorado Fuel and Iron Corporation, Pacific Coast Division, Oakland, Calif.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
National Standard Company, Niles, Mich.
Roebling's, John A., Sons Corp., Trenton, N. J.
Sheffield Steel Corp., Kansas City, Mo.
Wickwire Steel Div., Colorado Fuel & Iron Corp., New York, N. Y.

WIRE—Magnet
Kassel Export Company, New York, N. Y.

WIRE—Manufacturers
Alloy Metal Wire Div., H. K. Porter Company, Inc., Prospect Park, Pa.
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Bethlehem Steel Co., Bethlehem, Pa.
Chase Brass & Copper Co., Waterbury, Conn.
Colorado Fuel and Iron Corporation, Pacific Coast Division, Oakland, Calif.
Continental Steel Corp., Kokomo, Ind.
Crucible Steel Co. of America, Pittsburgh, Pa.
Johnson Steel & Wire Co., Inc., Worcester, Mass.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
Kaiser Aluminum & Chemical Corp., Oakland, Calif.
Keystone Steel & Wire Co., Peoria, Ill.
National Lock Washer Company, The, Newark, N. J.
Nichols Wire and Aluminum Company, Davenport, Iowa.
Pittsburgh Steel Co., Pittsburgh, Pa.
Roebling's, John A., Sons Corp., Trenton, N. J.
Scovill Mfg. Co., Waterbury, Conn.
Sheffield Steel Corp., Kansas City, Mo.
Spencer Wire Corp., Union, N. J.
Titan Metal Manufacturing Co., Bellefonte, Pa.
U. S. Steel Corp., N. Y., N. Y.
Wickwire Brothers, Inc., Cortland, N. Y.
Wickwire Steel Div., Colorado Fuel & Iron Corp., New York, N. Y.
Youngstown Sheet & Tube Co., Youngstown, O.

WIRE—Molybdenum
Kassel Export Company, New York, N. Y.

WIRE—Music
Johnson Steel & Wire Co., Inc., Worcester, Mass.
Kassel Export Co., New York, N. Y.
Malin & Co., The, Cleveland, Ohio
Spencer Wire Corp., Union, N. J.

WIRE—Nickel Silver and Phosphor Bronze
Alloy Metal Wire Div., H. K. Porter Co., Inc., Pittsburgh, Pa.
Chase Brass & Copper Co., Waterbury, Conn.
Malin & Co., The, Cleveland, Ohio
Titan Metal Manufacturing Co., Bellefonte, Pa.

WIRE—Oil Tempered
Crucible Steel Co. of America, Pittsburgh, Pa.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
Pittsburgh Steel Co., Pittsburgh, Pa.
Roebling's, John A., Sons Corp., Trenton, N. J.
Sheffield Steel Corp., Kansas City, Mo.

WIRE—Silver Plated Copper
Camden Wire Co., Camden, N. Y.
Kassel Export Co., New York, N. Y.

WIRE—Special Shapes
Alloy Metal Wire Div., H. K. Porter Co., Inc., Pittsburgh, Pa.
Continental Steel Corp., Kokomo, Ind.
Crucible Steel Co. of America, Pittsburgh, Pa.
National Lock Washer Company, The, Newark, N. J.
Titan Metal Manufacturing Co., Bellefonte, Pa.

WIRE—Spring
Alloy Metal Wire Div., H. K. Porter Co., Inc., Pittsburgh, Pa.
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Bethlehem Steel Co., Bethlehem, Pa.
Colorado Fuel and Iron Corporation, Pacific Coast Division, Oakland, Calif.
Continental Steel Corp., Kokomo, Ind.
Crucible Steel Co. of America, Pittsburgh, Pa.
Johnson Steel & Wire Co., Inc., Worcester, Mass.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
National Standard Company, Niles, Mich.
Pittsburgh Steel Co., Pittsburgh, Pa.
Roebling's, John A., Sons Corp., Trenton, N. J.
Sheffield Steel Corp., Kansas City, Mo.
Wickwire Steel Div., Colorado Fuel & Iron Corp., New York, N. Y.
Youngstown Sheet & Tube Co., Youngstown, O.

WIRE—Stainless Steel
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Crucible Steel Co. of America, Pittsburgh, Pa.
Firth Sterling, Inc., Pittsburgh, Pa.
National Lock Washer Company, The, Newark, N. J.
National Standard Company, Niles, Mich.
Pittsburgh Steel Co., Pittsburgh, Pa.

WIRE—Steel—Also Coppered and Galvanized Steel
Alloy Metal Wire Div., H. K. Porter Co., Inc., Pittsburgh, Pa.
American Steel & Wire Div., United States Steel Corp., Cleveland, O.
Bethlehem Steel Co., Bethlehem, Pa.
Colorado Fuel and Iron Corporation, Pacific Coast Division, Oakland, Calif.
Continental Steel Corp., Kokomo, Ind.
Crucible Steel Co. of America, Pittsburgh, Pa.
Johnson Steel & Wire Co., Inc., Worcester, Mass.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
Jury's Wire Products, Inc., Bloomfield, N. J.
Keystone Steel & Wire Co., Peoria, Ill.
National Standard Company, Niles, Mich.
Pittsburgh Steel Co., Pittsburgh, Pa.
Roebling's, John A., Sons Corp., Trenton, N J.
Sheffield Steel Corp., Kansas City, Mo.
Spencer Wire Corp., Union, N. J.
U. S. Steel Export Co., New York, N. Y.
Wickwire Brothers, Inc., Cortland, N. Y.
Wickwire Steel Div., Colorado Fuel & Iron Corp., New York, N. Y.
Youngstown Sheet & Tube Co., Youngstown, O

WIRE—Straightening and Cutting
Colorado Fuel and Iron Corporation, Pacific Coast Division, Oakland, Calif.
Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
Wickwire Brothers, Inc., Cortland, N. Y.
Wickwire Steel Div., Colorado Fuel & Iron Corp., New York, N. Y.

WIRE—Tinned Copper
Camden Wire Co., Camden, N. Y.
Jury's Wire Products, Inc., Bloomfield, N. J.
Kassel Export Co., New York, N. Y.
Spencer Wire Corporation, Union, New Jersey
Utica Wire Corp., Derby, Conn.

WIRE—Tungsten
Kassel Export Company, New York, N. Y.

WIRE—Zinc
Platt Bros. & Co., The, Waterbury, Conn.

WOOD—for Guide, Rolls, Bushings, Wear Parts, etc.
Lignum-Vitae Products Corp., Jersey City, N. J.

WRAPPING PAPER—Creped
(See PAPER—Creped Wrapping)

YARNS & TAPES—Insulating
Celanese Corporation of America, New York, N. Y.
Pittsburgh Plate Glass Company, Pittsburgh, Pa.
Standard Film Products Corp., Pawtucket, R. I.
Synthetic Thread Corporation, Bethlehem, Pa.

YARN TESTERS—
Scott Testers, Inc., Providence, R. I.

The WATSON MACHINE COMPANY

ESTABLISHED 1845

PATERSON 3, NEW JERSEY, U. S. A.

ELECTRICAL WIRE AND CABLE, WIRE ROPE, CORDAGE
AND MASTICATING MACHINERY MANUFACTURERS

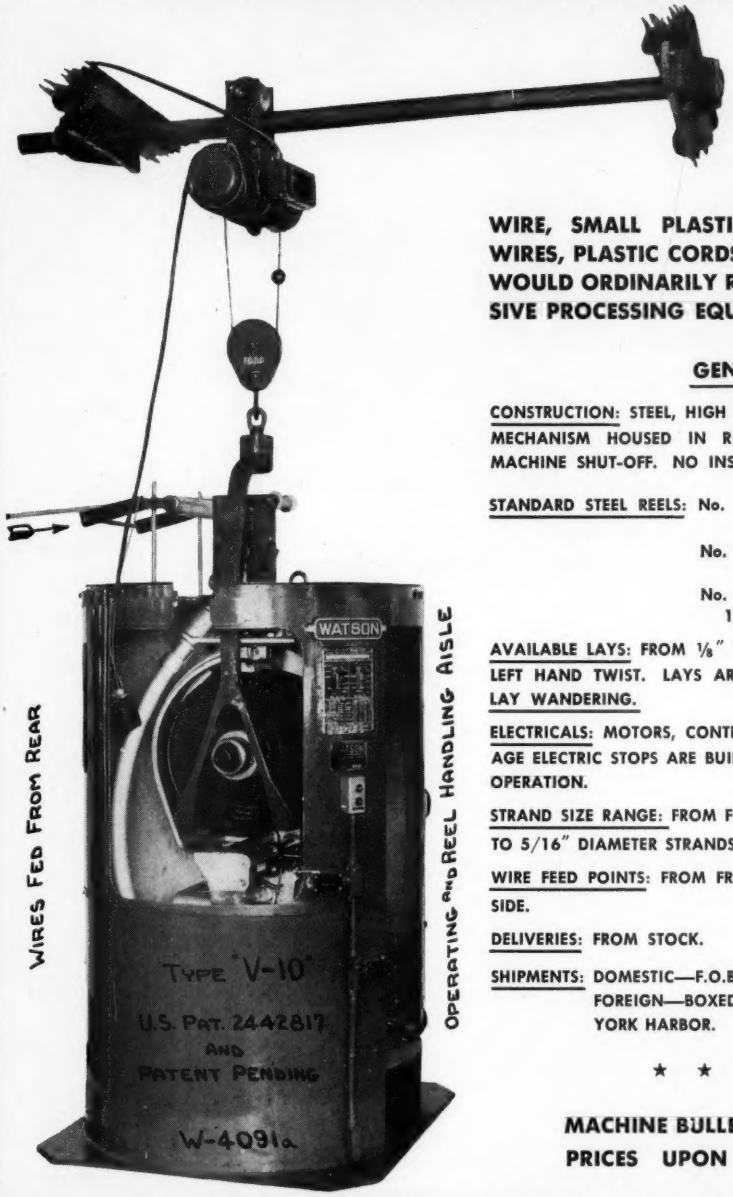
WATSON

VERTICAL BUNCHERS TYPE "V"

THE LEADING DESIGNS WITH AN INTERNATIONAL REPUTATION

NOTABLE ADVANTAGES:

1.—HIGHEST LONG-RUN OUTPUT ON LARGE STANDARD WIRE REELS.
2.—GREATEST COMPACTNESS. IDEAL FOR ROW GROUPING IN LIMITED SPACE.
3.—LABOR-SAVING. ONE OPERATOR CAN SERVE MANY MACHINES.
4.—QUICKEST PARTS SERVICE FROM CATALOGUED STOCK.
5.—LOWEST MACHINE COST DUE TO MASS MANUFACTURE.



SUITABLE FOR ALL COMMON BUNCHING WORK, AND USED ALSO FOR BUNCH-STRANDING AND CABLING OF STEEL AND ALUMINUM CLOTHESLINE, TELEVISION GUY WIRE, SEALING STRANDS, METAL FISH LINES, PAPER CORD, CONTINUOUS TWISTS OF FLAT WIRE, SMALL PLASTIC INSULATED CABLES, ANNUNCIATOR WIRES, PLASTIC CORDS, AND MANY OTHER PRODUCTS WHICH WOULD ORDINARILY REQUIRE THE USE OF MUCH MORE EXPENSIVE PROCESSING EQUIPMENT.

GENERAL SPECIFICATIONS

CONSTRUCTION: STEEL, HIGH STRENGTH ALLOYS AND BALL BEARING THROUGHOUT. MECHANISM HOUSED IN RIGID STEEL FRAME WITH SAFETY DOOR OPENING MACHINE SHUT-OFF. NO INSTALLATION WORK REQUIRED.

STANDARD STEEL REELS: No. 7—16" x 8", 250 LB. CU. CAPACITY
No. 9—22" x 11", 650 LB. CU. CAPACITY
No. 10—24" x 14", 1000 LB. CU. CAPACITY

AVAILABLE LAYS: FROM 1/8" TO 4 7/8". RIGHT AND LEFT HAND TWIST. LAYS ARE FIXED AS SET. NO LAY WANDERING.

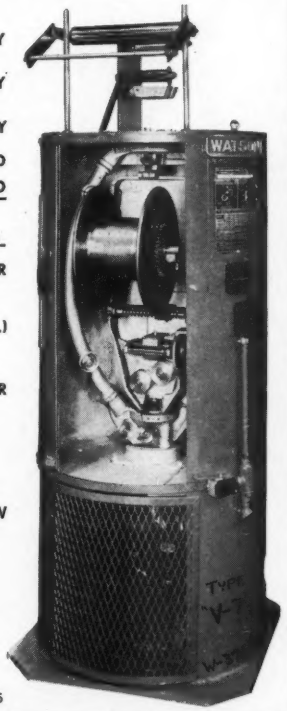
ELECTRICALS: MOTORS, CONTROLS AND LOW VOLTAGE ELECTRIC STOPS ARE BUILT IN AND WIRED FOR OPERATION.

STRAND SIZE RANGE: FROM FINE (7 x #30 B. & S.) TO 5/16" DIAMETER STRANDS.

WIRE FEED POINTS: FROM FRONT, REAR OR EITHER SIDE.

DELIVERIES: FROM STOCK.

SHIPMENTS: DOMESTIC—F.O.B. PATERSON, N. J.
FOREIGN—BOXED & DELIVERED TO NEW YORK HARBOR.



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MACHINE BULLETINS AND PRICES UPON REQUEST

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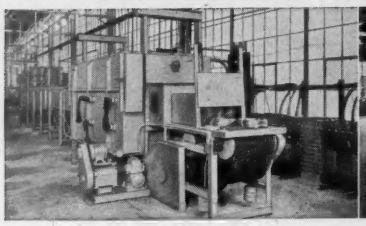
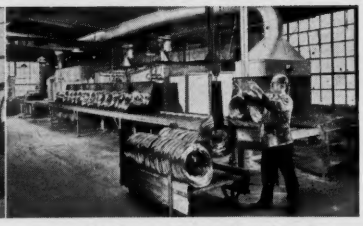
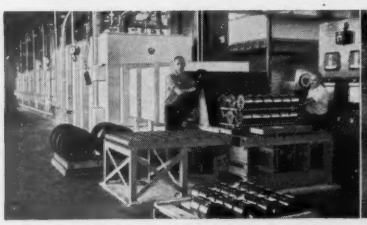


EF belt conveyor furnace bright annealing coiled alloy steel and non-ferrous wire.



EF continuous roller rail pusher furnace, bright anneals large reels and coils of wire.

designed engineered and



This furnace bright anneals wire on reels, spools, and coiled. Capacity 4000 lbs. per hr.

Stainless steel wire is bright annealed continuously in these EF multiple tube furnaces.

Specially Built

to meet the WIRE INDUSTRY'S requirements

Charging end of EF special atmosphere bulkhead pusher furnace; bright anneals copper and copperweld wire and clean anneals brass wire. Capacity 4000 lbs. per hr.

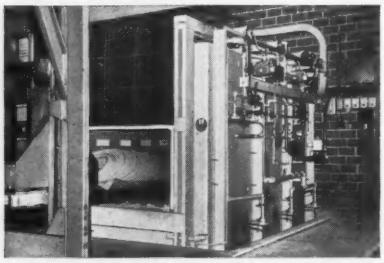
• We build production furnaces for heat processing all kinds of wire, rod, or other products — in any shape or form.

Years of practical experience in designing and building successful heat treating equipment for the wire industry enable us to furnish the best type of equipment for any purpose — and to produce the results required.

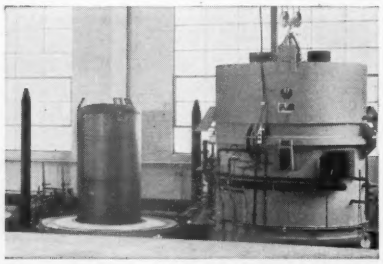
Shown here are 8 more production installations we made in prominent wire plants. We receive many repeat orders.

Submit your production furnace problems to experienced EF engineers — it pays.

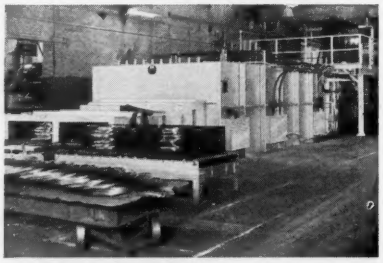
THE ELECTRIC FURNACE CO.
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS PRODUCT OR PRODUCTION
Salem - Ohio
Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada



EF direct gas fired, single end, forced circulation hearth type annealing furnace with gantry crane for handling large coils of cupro nickel wire and brass rod.



EF direct gas fired bell type furnace with retorts and 4 forced circulation bases, used for bright annealing both ferrous and non-ferrous flat coiled wire.



EF special atmosphere continuous bright annealing furnace in which the wire is conveyed through the various zones on two parallel rows of bulkhead type trays.